United States
Department of
Agriculture

Forest
Service

General
Technical
Report
WO-35

Improved Forest and Range Land Productivity Through Research

1982 Research Accomplishments

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July 1983

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Foreword

I am pleased to distribute this report of our Research organization for 1982. It represents the work of our own scientists as well as that of many cooperators in other Federal and State agencies, universities, and private organizations.

The theme of this year's report is improving forest and range land productivity through research, an appropriate symbol for the direction our Research program must take in the decades ahead. New knowledge through research is vital to 20th century living. A growing population, with increased demands for goods and services, requires new biological and technological information. Research is conducted in many fields: Forest genetics, silviculture, integrated pest management, forest engineering, hydrology, and wildlife biology, to name a few.

This report reflects that diversity. You will find a fascinating account of research from the Forest Products Laboratory on the way fungi oxidize or "burn" lignin in the decomposition process. This work may lead to better ways of protecting wood from decay and more effective processes to treat the lignin-bearing wastes from pulp and paper mills. At the Pacific Southwest Station, researchers have determined the "lifting windows"—the time period during which Douglas-fir seedlings can safely be lifted in the nursery and stored for later planting. At the Northeastern Station, researchers have developed a data base to predict the effects of surface mining and reclamation activity on streamflow and water quality. You will also read about our efforts to share technical information with China and of the possibility of importing natural biological agents from China for control of the gypsy moth. In all, the emphasis is to find better ways to use our forest resources and to protect the essential land base for future use and enjoyment.

No research is conducted in a vacuum. It requires input and coordination with field forestry personnel at every stage. And it requires a commitment to change existing forestry practices, as new information shows us better ways of doing a job. As forestry professionals, we have a long-term interest in the development of new knowledge and in its application in the field.

Research is conducted at eight Experiment Stations and their field locations and the Forest Products Laboratory. A list of principal Research headquarters is on page page 167.

The highlights are only a sample of the new knowledge and technology developed this past year. A list of publications, beginning on page 61, completes our review of the year's research in progress.

R. MAX PETERSON

Chief

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Research Publications

Research Publications (cont.)

Acknowledgment

J. Louise Parker, Group Leader for Research Information Services at the Pacific Northwest Forest and Range Experiment Station, edited and coordinated production of this report.

Products and Engineering

Basic Research Shows That Fungi "Burn" Lignin

Long-term basic research at the Forest Products Laboratory has begun to unravel a mystery that has puzzled scientists for decades: How is lignin—the natural plastic that comprises about 30 percent of wood—degraded by fungi? With its large and irregular molecules, lignin is a complex compound that would appear to be very difficult to degrade.

From laboratory studies, scientists have found that the fungi chemically oxidize or "burn" the lignin outside the fungi's cells, a phenomenon unique among the earth's major biopolymers. Fragments produced from the chemical breakdown of lignin are taken up by the cells of the fungi and further digested. Even so, the process is a net consumer of biological energy: The fungi obtain little or no nutrients from the lignin. Apparently, the fungi consume the lignin to get at the nutrients they need from the wood—either hemicellulose or cellulose.

This important discovery enhances our basic understanding of the physiology of fungi; it may lead to better ways of protecting wood from decay and to more effective processes for treating the lignin-bearing wastewater from pulp- and papermills.

Scientists used "heavy oxygen," analyzed by mass spectrometry, to establish the role of oxygen in the breakdown of lignin by fungi.

New Topwood Harvester Cuts Down on Waste

When northern hardwoods are harvested for sawtimber, an estimated 40 to 50 percent of tree weight above the stump is left in the woods in the form of tops and limbs. In the Eastern United States alone, over 50 million dry tons of residue are wasted this way each year.

A new topwood harvester has been developed by engineers at the North Central Station in cooperation with the Tennessee Valley Authority. The harvester compacts large, mushrooming treetops by mechanically severing the limbs. It then alines the limbs with the main stem to avoid damaging live trees while skidding (dragging logs from the harvesting site).

The carrier vehicle has a telescoping boom loader with a unique cutter head/grappler that can hold, cut, and load limbs into a U-shaped clamp located at the rear of the machine. The grapple can securely hold material up to 22 inches in diameter, and the rotating auger can cut limbs up to 11 inches in diameter.

Researchers are testing the new harvester to determine cost and productivity under various site conditions. Adoption of this means of harvesting will eliminate much of the waste now associated with logging throughout the eastern hardwood region.

Artists's conception of topwood harvester processing tops of hardwood trees that would normally be wasted in the logging process.

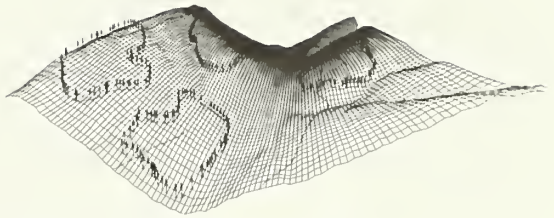
Computers Used in Timber Harvest Planning

Computer planning tools are increasingly used in modern forestry to hold down logging costs. Advances in computer technology have enabled researchers to attack the complex problems of logging systems selection and use. Two new programs have been developed.

PLANS (Preliminary Logging Analysis System) is a group of computer programs developed at the Pacific Northwest Station to prepare cost-effective, thorough, and rapidly produced timber harvesting plans. PLANS uses computer-stored terrain models, which allow the planner to position trial road grades; analyze skyline reach and load characteristics; examine slope and aspect; and view cutting units, roads, and topography in perspective. PLANS is currently being used on a trial basis by numerous logging engineers on western National Forests, as well as by forest products companies and private consultants. Users report that PLANS is the best available methodology for cost-effective timber harvest planning.

Another computer planning tool, this one developed at the Northeastern Station, uses the "weak link" concept to select the proper number of machines, workers, and operating times so that logging systems are balanced for optimum efficiency. The concept is that harvest production and efficiency are controlled by the least productive function (weak link) of the logging system—felling, skidding, loading, or hauling—and that the production rate of all functions should be reduced to that of the weakest link. The program gives production and cost rates per 1,000 board feet for each function or for the total system.

The Weak Link Program was prepared for hand-held calculators. It is easy to use: A series of prompts appear on the screen to indicate what data to enter, and the answer is given in cost per 1,000 board feet. The program will be of most use to logging contractors but will also find applications in forestry education and extension work.



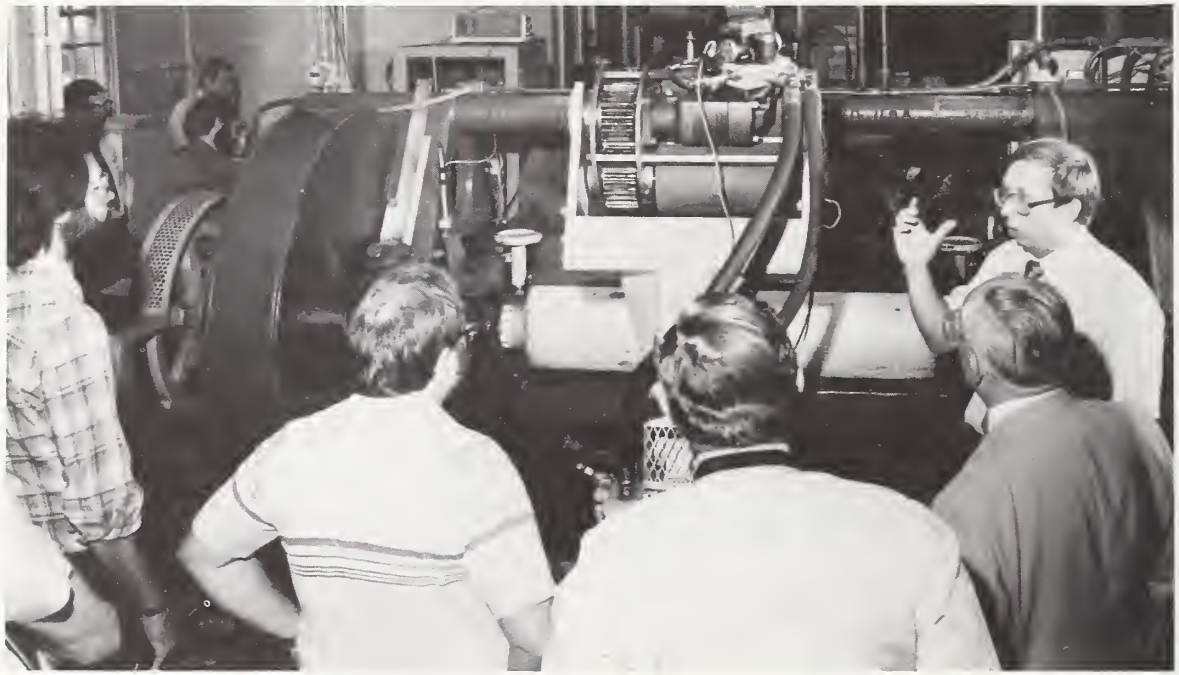
Computer-stored terrain models enable planners to evaluate many aspects of timber harvest planning.

Powered Backup Roll Saves Logs in Veneer Processing

Scientists at the Forest Products Laboratory have developed a powered backup roll (PBR) that reduces log spinout while veneer sheets are being peeled. Spinout occurs on an average of 5 to 8 percent of all logs that are considered peelable. It happens when the torque required to peel a log exceeds the torque that can be transmitted by the chucks. The powered backup helps turn the log.

Because of the successful performance of the prototype, Boise Cascade's plywood plant in Yakima, Wash., installed a commercial model. The PBR reduced veneer loss caused by spinout by two-thirds, fit in well with the normal veneer peeling operation, and made a hit with plant personnel.

Nationally, the new device has a potential for saving $75 million per year in damage to high-value logs during the peeling process. This is equivalent to 42 million cubic feet of veneer recovered. Based on this success story, at least two lathe equipment manufacturers are receiving orders from other plywood plants that want their own PBR.



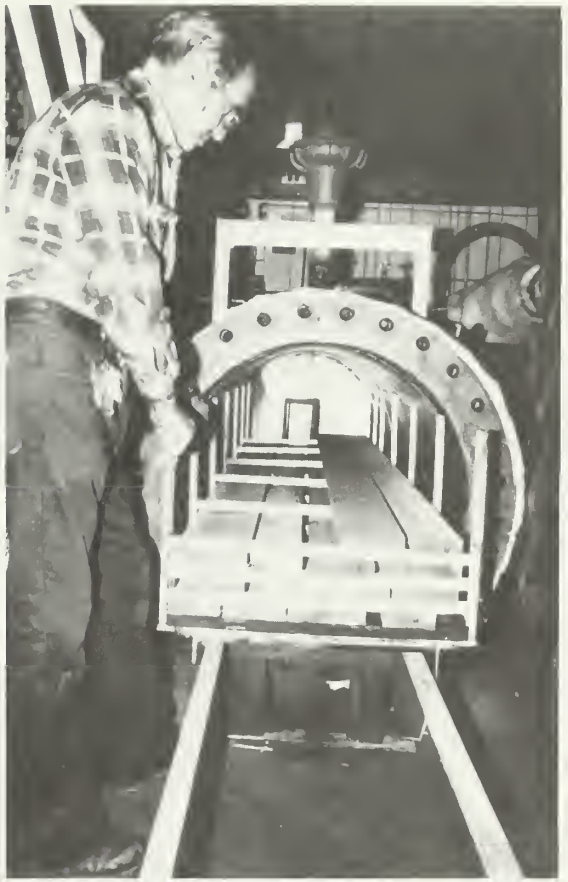
Benefits of powered backup are explained to industry representatives at the Forest Products Laboratory by inventor Frank Fronczak (right).

New Technique Speeds Lumber Drying

Conventional kiln drying is a major bottleneck in the process of converting logs to lumber. It takes more time, energy, and money than any other step in wood processing. Scientists at the North Central Station have developed an improved process called pressure steam drying, in which lumber is dried under high pressure in superheated steam generated by the lumber itself. The process is faster, more efficient, and cheaper than conventional kiln drying. Scientists at the North Central Station now hold a Government patent for the process.

In tests using 1-inch-thick yellow-poplar, river birch, silver maple, white ash, and air-dried black walnut and red oak, it took only 20 to 43 hours to dry the lumber to a moisture content of 6 percent, a process that normally takes 5 to 7 days. Pressure steam drying darkened the wood, but degrade was less than 3 percent of the total lumber value.

Researchers are continuing their work by testing other species and thicker pieces of wood. They are also working on the possibility of recovering energy from the drying process. The byproduct of the process is pure steam, which is easier to recover and use for other purposes than the air and steam created by conventional kiln drying.



Pressure steam drying, a process developed at the North Central Station, is faster, more efficient, and cheaper than conventional kiln drying.

Report Published on Wood Preservatives

The use of wood preservatives to extend the life of wood structures saves about 2.3 billion cubic feet of wood annually in the United States. If registration of the three main wood preservatives—coal-tar creosote, pentachlorophenol, and inorganic arsenicals—were canceled, an additional cost of $6 billion annually would result as other chemicals were substituted or other structural materials replaced wood.

But there may be risks, as well as benefits, associated with the use of these chemicals. In 1978, the U.S. Environmental Protection Agency (EPA) asked the U.S. Department of Agriculture for help in assessing the risks. The Forest Products Laboratory led an assessment team of 21 specialists from other Government agencies and universities. Their 700-page report, "Biologic and Economic Assessment of Penta, Inorganic Arsenicals, and Creosote," was completed in November 1980 and is being used by the EPA as a basis for decisions regarding reregistration of these preservatives. Copies of the report are also available to the public.

Copper chrome arsenate stain is applied to protect exterior of rural farm building.

Construction Guide Promotes Truss-Framed System

The Truss-Framed System (TFS), developed for house construction by the Forest Products Laboratory, is an innovative system that incorporates floors, walls, and roof into a unitized frame. It overcomes conventional construction weaknesses in the connections between the floors, walls, and roof. The result is a stronger structure with better ability to survive severe windstorms or earthquakes. It is also less costly than conventional construction.

Builders using the TFS produce quality houses that cost significantly less than houses with typical light-frame construction. Savings of 10 percent are commonly reported with TFS and even greater savings can be achieved by combining TFS with other new housing technologies. Savings are mainly obtained by minimizing the time and labor involved in erecting a home. Other advantages may include savings up to 30 percent in the quantity of structural framing lumber. To date, builders have constructed more than 1,000 TFS homes throughout the United States and more are being built every day.

A construction manual prepared by the Forest Products Laboratory in cooperation with the National Association of Home Builders Research Foundation provides the information needed to design and build various structures using the Truss-Framed System. The manual, "Truss-Framed Construction, A Manual of Basic Practice," is for sale by the Research Foundation. It answers some common questions about design, fabrication, and installation of the system and recommends manufacturing guidelines and building procedures.

The Truss-Framed System saves time, materials, and money for builders and homeowners.

New Adhesives System Strengthens Wood Foundations

A major drawback of wood foundations has been the need to use corrosion-resistant metal fasteners because ordinary nails rust or corrode and rapidly lose strength in damp conditions. Stainless steel nails, which are quite durable, are expensive and significantly increase the cost of wood foundations. Hot dip galvanized nails are cheaper, but less durable.

An alternative is to glue the plywood onto the studs and eliminate, or greatly reduce, the need for nails. At the Southeastern Station, researchers have succeeded in using a phenol-resorcinol adhesive to join foundation members together. When an alkali solution is applied before the adhesive, the joints on glued walls are twice as strong as nailed joints. When unplaned treated plywood and lumber are used, large gaps at joints often result. When the adhesive is used, it fills the gaps and creates a better bond.

The result is a wood foundation with few metal fasteners—and a joint strength that far exceeds minimum standards. Not only is the joint stronger, but the entire construction is stronger. Gluing makes the stud-wall joint function as a T-beam, which allows the stresses to be more equalized. As a result, there is potential to further reduce costs by using smaller studs or spacing them farther apart.

This research is a promising step toward solving problems associated with wood foundations. But additional work is necessary to simplify the gluing process and make it more attractive to manufacturers.

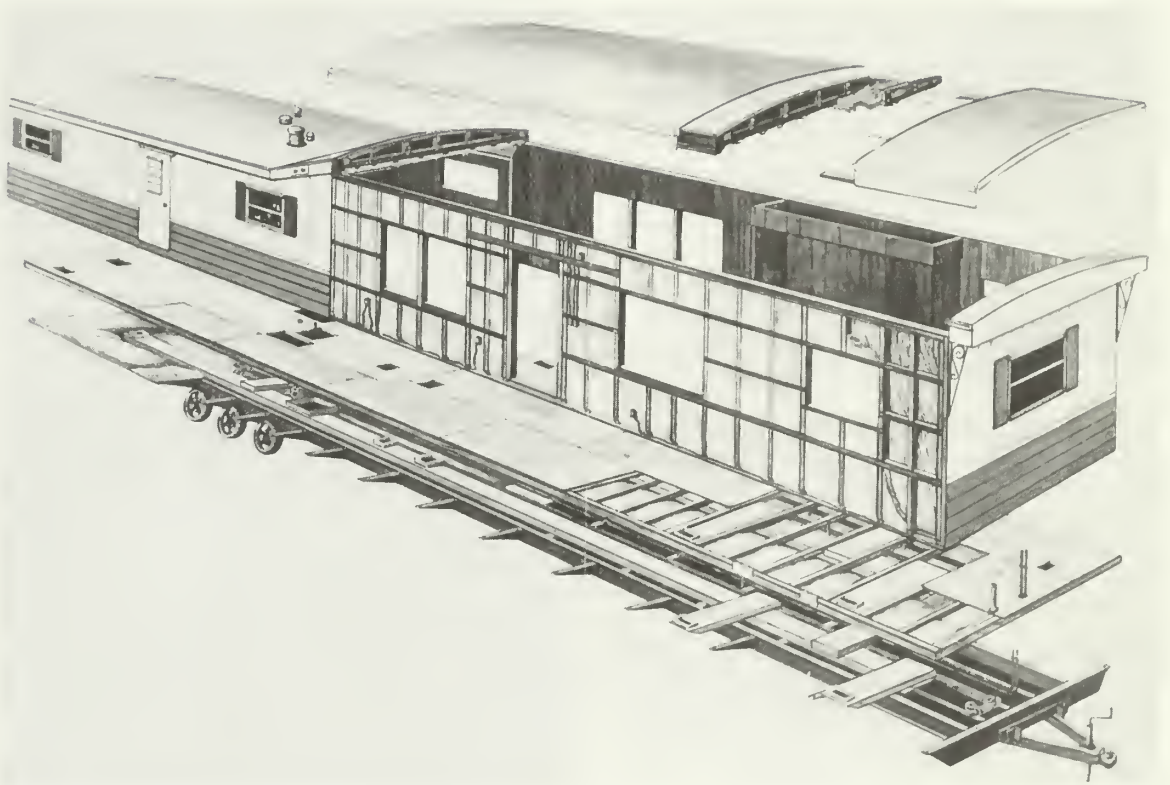
Adhesive is applied to a wood foundation in preparation for testing.

Emission Standards Developed for Formaldehyde in Mobile Homes

Particle board and decorative plywood paneling are popular wood products that use urea formaldehyde-based adhesives. Extensive use of these products, however, can cause harmful levels of formaldehyde in indoor air, which can be uncomfortable and possibly harmful.

For the past 5 years, the Forest Products Laboratory (FPL) has been working with other Government agencies and industry to develop better ways to predict and measure the amount of formaldehyde that escapes into the air from various types of panel products. Their work has resulted in many technical papers and in better ways to relate the data from various emission tests to levels of air pollution. Several techniques in use in other countries have been tested and compared to determine which gives best results with wood products under actual-use conditions. Results of this work have been valuable to both manufacturers and users of interior panel products.

Recently, and with guidance from the FPL, the Department of Housing and Urban Development has incorporated a formaldehyde emission standard for interior panels in its proposed product standard for mobile homes. By meeting this standard, panel manufacturers can greatly reduce the formaldehyde contamination levels in all living spaces.



Mobile home (cutaway view) shows many panel wood products that use urea-formaldehyde adhesives.

ALPS System Improves Production of Furniture Parts

A new Automated Lumber Processing System (ALPS) may drastically change the way wood products are produced in the future. ALPS is being developed at the Southern Station in an effort to improve efficiency and yield in the production of furniture parts. The system has three stages: (1) Tomography, (2) detection of different types of defect by image analysis, and (3) laser cutting. Computer programs now under development are used at each stage of the process.

In the first stage—tomography—the log is scanned with X-rays to locate internal knots and defects. Using this information, a computer program positions the log to improve the grade of boards produced during sawing.

After the boards are dried and surfaced, they are scanned by optical image analysis methods that measure the tonal and pattern variations in light intensity. A computer program records the type, size, and location of the surface defects and computes the optimum cutting pattern for each board to produce the maximum number of good parts.

Furniture parts are then cut by use of a high-power laser controlled by another computer program. Advantages of laser cutting are numerous. Most important is the small kerf and the ability to start and stop cutting at any location.

High-power laser, controlled by a computer program, has several advantages for sawing lumber: a small kerf and the ability to start and stop cutting at any location.

New Performance Standards Approved for Corrugated Containers

Research at the Forest Products Laboratory (FPL), in cooperation with the American Society for Testing and Material (ASTM) and industry, has resulted in a newly approved ASTM standard for testing shipping containers. the standard is based in part on research, which was conducted at FPL several years ago and defined the shipping environment for both rail and motor freight in the United States.

The new standard more fully insures adequate performance and efficient use of materials. Unlike the existing rail and motor freight standards, which are based on the weight of the paperboard and "burst" strength, the new procedure includes a sequence of tests representing the hazards and conditions that occur in shipment and storage.

Such performance tests will help maintain product quality, reduce shipping damage, and improve wood utilization by eliminating overpackaging. This is especially significant because 90 percent of all shipments are made in corrugated containers and one-eighth of all wood cut is used to make such containers. In addition, the standard permits more use of hardwoods and recycled fibers in the manufacture of corrugated containers.

Load of corrugated shipping containers is tested for performance at the Forest Products Laboratory.

Resource Economics

Assessing Utilization Potential of Forest Biomass

In all regions of the country, Forest Service researchers are looking at the timber resource in a new way: as a potential source of energy. A developing market for wood as an alternate fuel source offers new opportunities for utilizing logging residues and low-quality trees. But potential users need to know how much fuelwood is available, where it is, its characteristics, and how it can be economically harvested.

At the Southeastern Station, scientists have developed techniques for estimating the weight and volume of the total tree and product components, including fuelwood, for the southern pines and important hardwood species. The techniques are being incorporated into the Forest Service's forest inventory program for area and regional assessments of total biomass.

At the Intermountain and Pacific Northwest Stations, scientists have examined the feasibility of recovering large quantities of wood and bark residues after logging. Their work is contained in two publications. The first, "Logging Residue in the Pacific Northwest: Characteristics Affecting Utilization," Research Paper PNW-289, describes the characteristics of residue material in Oregon, Washington, and Idaho that affect its potential use for energy and other products. The second paper, "Ratios for Estimating Logging Residue in the Pacific Northwest," Research paper PNW-288, describes a method to estimate the amount of logging residue in an area, using ratios that relate the quantity of residue to the volume of timber or number of acres harvested.

At the Intermountain and Pacific Northwest Stations, scientists have examined the feasibility of recovering large quantities of wood and bark residues from logging operations.

Midcycle Inventories Monitor Changing Timber Resource

For years, the Forest Service has conducted timber and resource inventories in the mid-South on a 10-year cycle; however, statistics are often outdated. Inventory changes caused by conversion of forest land to other uses or by timber harvest, fire, insects, and disease make current information obsolete. More intensive forest management requires more timely inventory information. The big problem is cost.

A new, low-intensity inventory procedure developed at the Southern Station will help meet resource managers' needs for more timely information. The procedure was used for a midcycle inventory of timber resources in Louisiana in 1980. Using high altitude aerial photography, forest acreage was determined at the National Forestry Applications Laboratory, Johnson Space Flight Center, a Forest Service facility in Houston, Tex. In addition, about 220 field plots from the regular survey were remeasured cooperatively by crews from the Southern Station and the Louisiana Office of Forestry. The Louisiana Department of Natural Resources also provided financial assistance.

The midcycle inventory was highly successful. Inventory estimates can be made at 5- rather than 10-year intervals, at a cost of one-tenth that of regular surveys. Although this procedure is no substitute for the detailed county-level information that results from regular surveys, it does yield acceptable statewide timber resource estimates. These procedures have been used to produce midcycle estimates for Oklahoma, and similar work has begun in Mississippi. The entire mid-South now has the option of reducing the inventory cycle to 5 years, and other regions are considering the use of these space-age procedures.

Use of high altitude photography is helping speed forest inventories in the South.

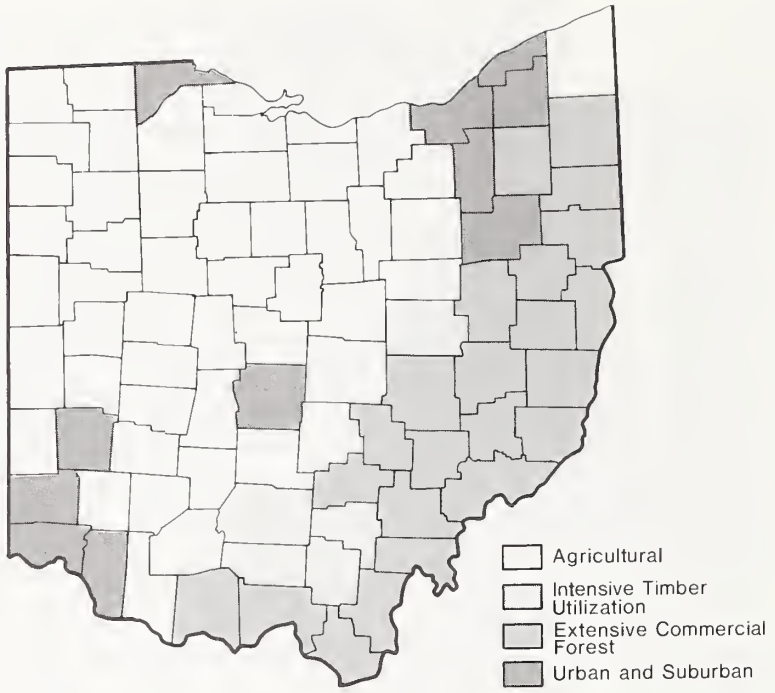
Inventory of Ohio Forests Shows Opportunities for Timber Recovery

As part of a reinventory of forest resources in Ohio, researchers at the Northeastern Station conducted utilization studies. Their findings will be useful in planning ways to make better use of the State's timber resource.

Researchers found that timber recovery in hardwood stands is directly related to the number of marketing alternatives; that is, the more products that can be produced, the better the utilization. For example, when timber was harvested for use in a single product, recovery averaged only 83 percent of the inventory estimate. But when use was anticipated in more than one product, for example in both saw logs and pulpwood, recovery exceeded the inventory volume estimate by 3 percent. This is possible because inventory estimates are generally based on the assumption of single-product recovery—usually saw logs.

In Ohio, 63 percent of the timberland owners, who own 52 percent of the forest land, indicated that in the past they harvested only a single product. Recent technological innovations, such as whole tree chipping and stump pulling, however, favor multiproduct harvesting for and increased wood recovery from future cuttings.

In a related study, researchers found that about 486,000 acres of forest land were cleared for other uses between 1968 and 1978. Timber recovery and use were highest where extensive commercial forests were close to a variety of wood markets, and lowest near agricultural regions and urban population centers. Of the 107 million cubic feet of timber cut during clearing, 32 million cubic feet were recovered and used for industrial products.



Counties in Ohio showing level of timber-based activity and utilization of timber after forest was cleared for other uses, 1968-78.

Nearly 8 Million Forest Owners Identified

Privately owned forests are expected to play an increasingly important role in supplying the wood resources this Nation needs. But how many owners are there, where are they, and how much do they own? A survey conducted for the Forest Service in 1978 provided many answers. The results of the survey were published in 1982 as Resource Bulletin WO-1, "The Private Forest-Land Owners of the United States."

There are 7.8 million ownerships. A vast majority of the private owners—7.2 million—are in the East. Seventy-one percent of all ownerships are small parcels of 10 acres or less. These ownerships, however, account for only 4 percent of the total privately owned forest land. Large ownerships (500 or more acres), though less than 1 percent of the total number, contain 50 percent of the forest land. An additional 7 percent of the ownerships, ranging from 100 to 500 acres, contain 30 percent.

About one-third of all private forest land is corporately owned, mostly by forest-based industries that control substantial tracts of land to sustain their operations. Over half the corporate land is in the South. Of the remaining private forest land, farmers hold 16 percent; white collar workers, 15 percent; retired persons, 14 percent; and blue-collar workers, 11 percent.

Over half the private forest land is in ownerships acquired since 1950, although nearly 16 percent has been in the same ownership for more than 40 years. The landowners generally live near their land—nearly 82 percent of noncorporate forest-land owners live in the county of their holdings, and 92 percent live in the same State.

The survey was a cooperative effort by the Northeastern Station, Forest Service State and Private Forestry, and the Economic Research Service, which sent 11,000 questionnaires to private forest owners. The information gathered will be important in planning new incentive programs for management of private forest lands throughout the country.

Privately owned forests are expected to play an increasingly important role in supplying the nation's wood. A recent survey has provided much information about forest owners.

Forestry Incentives Programs: They Are Working

At a time when Government programs are being closely scrutinized, it is not surprising that forestry incentives programs, which provide assistance for tree planting, are also being evaluated. One of the major criticisms has been that many of those who receive such assistance would plant the trees even without Government help. Over the years, the amount of Government assistance has varied widely, and people have argued over how much new planting the programs generated. Until recently, these arguments were speculative. Now, an economist at the Southeastern Station has developed a system for analyzing the effectiveness of forestry incentives programs: an econometric model of investment behavior for landowners that explains what determines their level of investment in reforestation.

The model was used to analyze the variation in reforestation investments in 10 Southern States between 1964 and 1979 and to determine how much of the variation was caused by changes in State and Federal programs for forestry assistance. The study indicated that cost-share programs induced new investment above what would normally be expected, based on market forces.

The conclusion is that forestry incentives programs work fairly well. The findings are good news for the South, where the majority of forest land is in private ownership. The analysis technique could also be used in other parts of the country, where private timberlands might, over the long term, contribute more to the total timber harvest.

An econometric model used to analyze private timber investments in the South may also be used in other parts of the country where private timberlands might, over the long term, contribute more to the total timber harvest.

Private Timber Investments Could Have Major Impacts

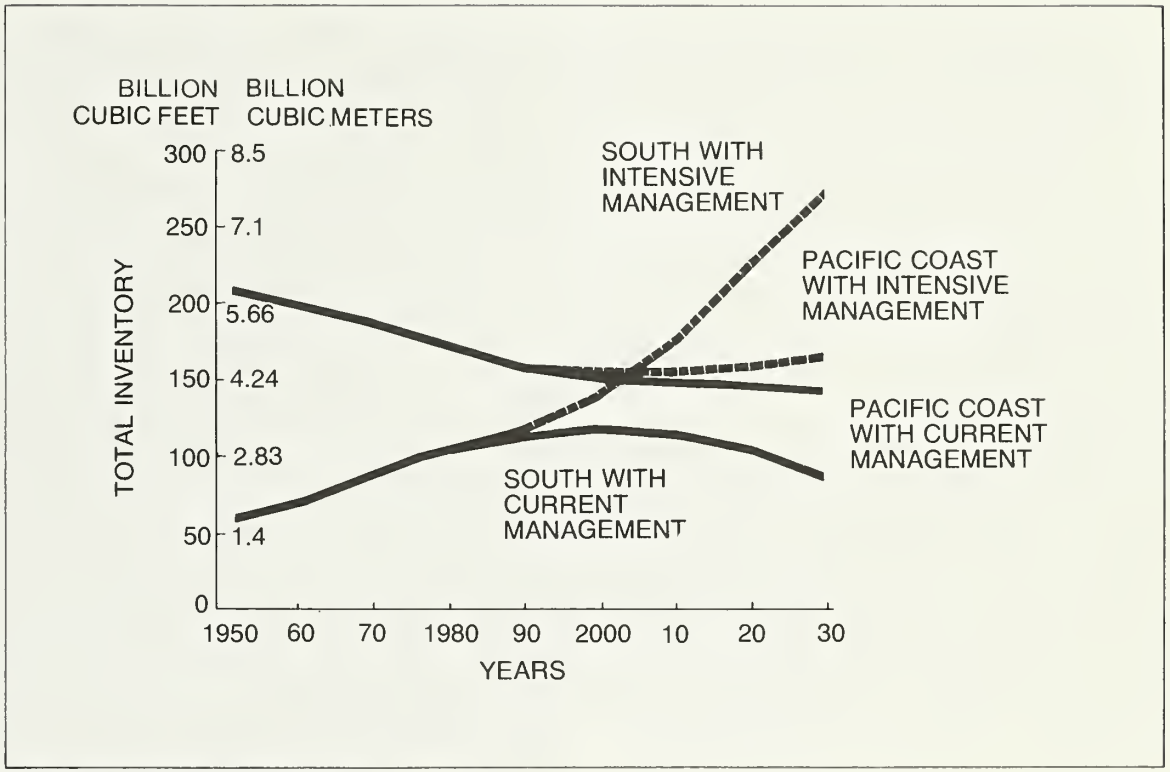
Investment by private owners in forest management can have a major impact on long-term prices and consumption behavior in forest products markets. A mathematical model, called the harvest investment model, explains the impact private owners can have on timber supplies. It was developed by the Pacific Northwest Station in conjunction with the Southeastern Station.

The model indicates that increasing private investment would have little effect on markets before the year 2000. Thus, public policies designed to augment timber supply in regions with declining harvest should rely on expanded harvest from public lands rather than accelerated investments on private lands, if they are to be effective in the short term.

Another effect of increased private investment would be to stabilize real wood product prices after the year 2000. Imports of softwood lumber would also be eliminated by 2030. Major gains in domestic production would replace lumber imports from Canada because they would no longer be competitive in the United States.

The model also predicts the expansion of wood product markets in southern forest regions. The South has roughly 9 times the commercial forest acreage of the Douglas-fir region in the Pacific Northwest and California combined, but nearly 12 times the area of manageable stands.

Information from this model has been used in the timber assessments required by the Resource Planning Act and by Forest Service State and Private Forestry to analyze the economic opportunities to increase softwood production on private land.

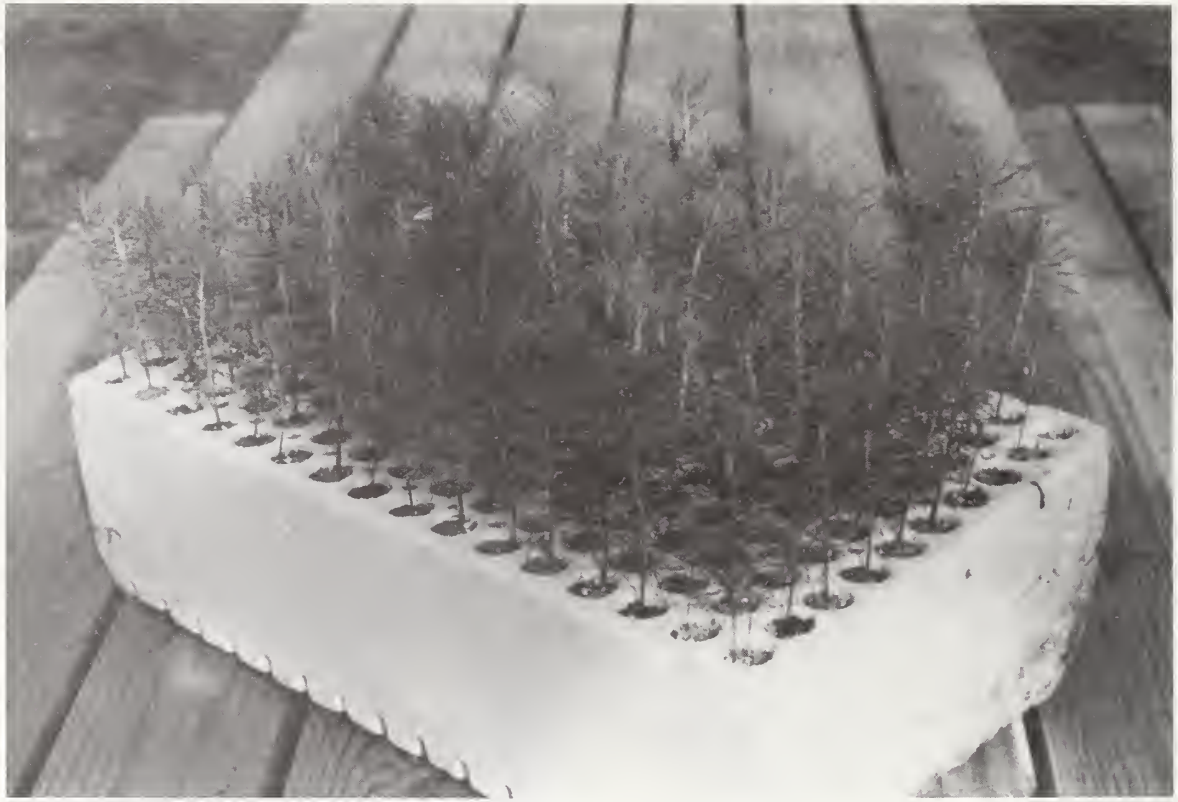


Growing stock inventory of timber for both the Pacific Coast and the South with current and intensive management.

It Is Economical To Grow Southern Pine Seedlings in Containers

Economic analyses show that it is economical to grow loblolly and longleaf pine seedlings in containers: The cost per 1,000 seedlings is as much as 10 percent less than growing bare-root seedlings in a new nursery. Of particular significance is the low initial cash outlay required for container nursery construction (less than half that of a new bare-root nursery) and the annual seedling output level at which production becomes economical (3 to 4 million container seedlings compared with 12 to 15 million bare-root seedlings). Nursery managers who want to expand seedling capacity can put a container nursery almost anywhere. Site quality requirements are minimal, and the acreage needed is small. Container nurseries can be in full production in less than a year.

Researchers at the Southern Station used construction and production cost records from the six pilot-scale container seedling nurseries in the South as the data base for their study. From that information, four full-scale, state-of-the-art nurseries were developed by combining the best features of the pilot-scale facilities. The results were presented at a 3-day conference in Savannah, Ga., which drew 125 attendees from throughout the United States and two foreign countries. As a result, two major forest products firms and a private nursery owner have built new nurseries for growing southern pine seedlings in containers.



Sixteen-week-old loblolly pine seedlings ready for outplanting. Styrofoam blocks are economical because they can be reused up to six times and stand rough handling.

Whole-Tree Chipping Has Potential for Energy

Researchers at the Northeastern Station have described results of a study conducted in Vermont to determine the potential of chipping whole trees to thin northern hardwood stands for fuel. The operation was judged to be economically marginal. But during the study, researchers identified several factors that are crucial for efficient and economical operations: (1) Landing sites should be designed to facilitate truck-van positioning and other landing activities; (2) Because the work is capital intensive, a larger portion of the scheduled hours must be productive time; and (3) Harvest sites should be located so that harvesting can continue in all types of weather.

Costs developed from the field studies also played a vital part in the planning for a 50-megawatt wood-fired electric generating plant in Burlington, Vt. The cost information was submitted to the Vermont Public Service Board during public hearings on the need for the plant. Production costs are also being used as part of a data bank on harvesting systems in the Northeast.

Computer simulation models have also been developed to simulate mechanized and conventional whole-tree harvesting operations in New England; they are being used to determine the productivity of and costs associated with whole-tree harvesting operations.

Several factors have been identified for efficient and economical whole-tree chipping operations.

Scientists Visit China

The first group of forest protection specialists to visit China from the United States made a 28-day trip in April and May 1981. The group included six specialists from the U.S. Department of Agriculture, Forest Service; three universities; and the New Jersey Department of Agriculture. Purpose of the visit was to explore opportunities for cooperation in forest insect and disease management. Funding for the trip was provided through the USDA Office of International Cooperation and Development, and travel arrangements were made by the Society of American Foresters.

On-the-ground observations and discussions with Chinese colleagues resulted in a better understanding of: (1) the major tree species in China and their insect and disease pests, (2) forest pest management practices, (3) insect and disease research and its role in forest management, and (4) education and training for pest management scientists and practitioners.

The visit set the stage for further exchange of information, biological control agents, and cooperative research. A followup visit was made by three scientists from the United States (Forest Service, Agricultural Research Service, and the Connecticut Agricultural Experiment Station) in 1982 to look for biological agents for control of the gypsy moth, an insect believed to have originated in China. Fifty-two locations were visited, and 13 parasites, 14 predators, and two diseases were collected and identified. The team returned with two disease organisms, which are currently being evaluated at the Forest Service's Center for Biological Control of Northeastern Forest Insects and Diseases, Hamden, Conn.

During a visit to China, American scientists explored the possibility of importing biological control agents to the United States for control of gypsy moth.

Information Summarized on Diseases of Pines and Firs in Shelterbelts

Pines and junipers are the backbone of many shelterbelts in the Great Plains because they maintain their foliage year around. The shelterbelts help protect soil, crops, livestock, wildlife, and dwellings from drying wind in summer and blowing snow in winter. Because the trees have been planted outside their normal environment, they are susceptible to a variety of diseases. Information about the diseases has been summarized in a new publication, "Pine and Juniper Diseases in the Great Plains," General Technical Report RM-86, from the Rocky Mountain Station. Information provided for nine of the most damaging diseases includes physiology and morphology, life cycle, diagnosis, damage, control, and prevention.

Emphasis in the publication is on reducing losses from disease in shelterbelts and nurseries through integrated pest management. Color photographs help users identify the diseases.

New pine shoots are examined for evidence of disease.

The spruce budworm is a major defoliator of spruce, fir, and Douglas-fir forests in North America. Millions of acres of timber are defoliated each year by the spruce budworm in the Northeast and the Lake States and the western spruce budworm in the West. Repeated, heavy defoliation can slow growth, reduce timber quality, inhibit regeneration, and cause top-kill and even death of trees.

Progress is being made in managing and controlling the budworms through reseach and development work under the Canada/United States Spruce Budworm Programs in both the East and the West.

In the West, a method called "radial increment analysis" has been developed to help determine the effect of the western spruce budworm on conifer regeneration and growth on young stands. It relies on a comparison of the width of growth rings of nonhost trees with those of trees on which the budworm has fed. The method has several applications in forest management: (1) to show the intensity and frequency of past outbreaks, (2) to determine the site and stand conditions that led to budworm outbreaks, (3) to hazard-rate stands for susceptibility to budworm attack, and (4) to prescribe appropriate silvicultural treatments to reduce budworm damage.

In the Lake States, a hazard-rating method that uses standard forest inventory data has been developed to identify stands vulnerable to spruce budworm damage. The rating scheme helps managers decide which stands to monitor for potential outbreaks, where to accelerate timber harvest if budworms are present, and which stands are most vulnerable to damage. The hazard-rating system permits forest managers to prescribe appropriate silvicultural practices and to integrate spruce budworm management with forest management.

The spruce budworms are major defoliators of spruce, fir, and Douglas-fir forests in North America.

Longleaf pine is an important southern pine that grows rapidly, has dense wood, is resistant to fusiform rust, and can grow well on sites that are too dry for other southern pines. But longleaf pine has one major drawback as a timber species: it is highly susceptible to brown-spot needle blight, a disease that affects the pine in the "grass stage"—the first 3 to 5 years the tree spends as a grasslike tuft before it elongates into a respectable tree form.

Over the years, landowners have cut much of the longleaf pine and replaced it with slash and loblolly pines. But species conversion has its problems, too. Although slash and loblolly pines are resistant to the needle blight, they are highly susceptible to fusiform rust. As a result, researchers have been looking for ways to solve the problems with longleaf pine and return it to its rightful place as an important timber tree.

During the grass stage, longleaf pine seedlings are vulnerable to the brown-spot needle blight and competition from other plants. Severe infection by the needle blight extends the grass stage for several years and can even kill the seedlings. Successful management of longleaf pine depends on forestry practices that promote early height growth and limit the needle blight during the first few years after seedlings are planted.

By tackling the problem from several angles, researchers at the Southern Station have made considerable progress. They have found that benomyl, a systemic fungicide, applied to the roots of seedlings before planting, significantly reduces brown-spot disease, increases survival, and stimulates early height growth. Working with scientists at the Southeastern Station, they have also improved survival and growth by inoculating seedbeds in nurseries with mycorrhizal fungi. Further, the benefits of benomyl and mycorrhizae are even more obvious when combined: More than 75 percent of seedlings treated with benomyl and having mycorrhizae initiated height growth within 3 years after planting. Herbicides and fertilizer also accelerate early growth. With the benomyl treatment and the use of herbicides and fertilizers in field plantations, 90 to 98 percent of seedlings attained rapid height growth during the second year after outplanting.

Goal of research is to hasten early growth of longleaf pine and to prevent infection by brown-spot needle blight.

Early Warning Developed fot the Webbing Coneworm

The webbing coneworm is a forest insect pest that can seriously reduce yields of genetically improved seed in loblolly pine seed orchards in the South. To help prevent such losses, scientists at the Southeastern Station have developed an "early warning" system to monitor coneworm populations and indicate when and where damage can be expected.

The system relies on the naturally occurring sex attractant (pheromone) of the female moth. The pheromone is a powerful attractant that in nature entices male moths to females for mating and reproduction. The chemical identity of the pheromone has been determined, enabling it to be synthesized and used in survey traps for monitoring purposes in the seed orchards. The number of male moths caught indicates the potential population size in the next generation and, therefore, potential damage that might be expected.

The pheromone was used in 1981 in 63 seed orchards in the Southern States where it proved successful in identifying places where unacceptable losses might occur. Use of the pheromone trapping system as an early warning device has several advantages over the present technology. It:

- Adds another weapon in the manager's arsenal for integrated pest management.

- Is relatively inexpensive, costing about $100 for materials to treat an orchard for a year.

- Makes protective insecticide applications in expectation of an outbreak unnecessary. This means less cost to the industry and more efficient use of insecticides.

- Increases the effectiveness of chemical sprays when they are required, by permitting more accurate timing of applications.

Installation of a pheromone trap used to catch webbing coneworm moths in loblolly pine seed orchards.

Insecticides Developed for Controlling Southern Pine Beetle

Outbreaks of southern pine beetles occur somewhere in the South almost every year and periodically become widespread and damaging. Although direct chemical control is often impractical in the woods, it can be effective for protecting high-value trees in yards, parks, campgrounds, seed orchards, and special-use forested areas. Chemical control, therefore, was a major part of the Expanded Southern Pine Beetle Research and Applications Program, begun in 1974. When the program began, only benzene hexachloride (BHC) and lindane were registered for beetle control, and their effects on the environment and on human safety were being questioned. All uses of BHC have since been canceled.

The program sponsored a large number of laboratory and field trials of many insecticides for use against the southern pine beetle. Research was conducted by university and Forest Service scientists with the goal of identifying insecticides and developing formulations and application strategies.

Three insecticides were identified as highly promising candidates and researched extensively: Chlorphyrifos, fenitrothion, and chlorpyrifos-methyl. Chlorpyrifos (Dursban^{R}) has now been registered by the U.S. Environmental Protection Agency and is being used to reduce or prevent damage caused by southern pine beetles.

Insecticides are applied to beetle-infested bolts to test their effectiveness in preventing brood emergence.

Device Simulates Aerial Spraying

An aerial spray simulator is being used at the Pacific Southwest Station to more accurately simulate the application of insecticides from aircraft. The simulator is used to spray field-grown trees 3 to 12 feet tall. A frame, which adjusts to the height of the tree, supports a motor-driven, battery-powered insecticide applicator equipped with nozzles that duplicate the spray pattern, spray volume, and size of droplets delivered in a helicopter spray operation.

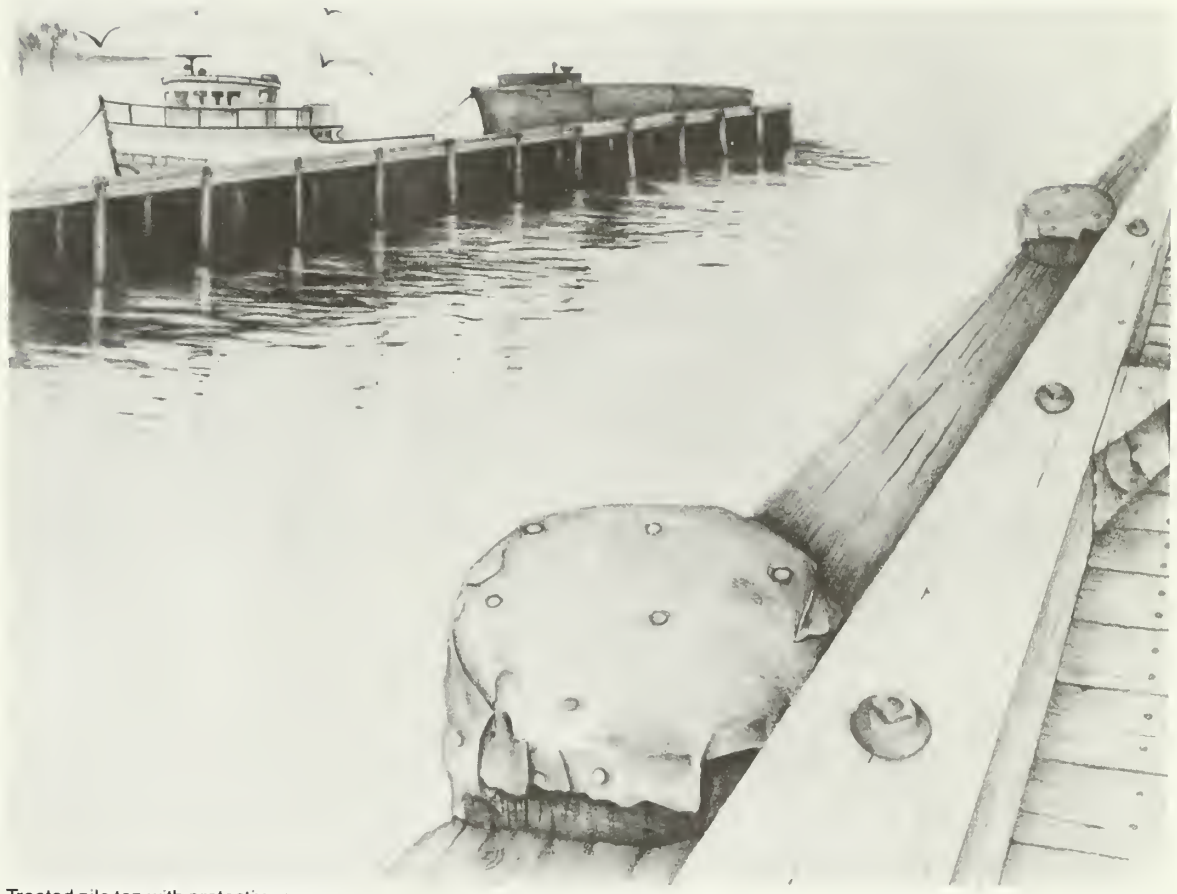
The simulator enables researchers to conduct small field tests of candidate insecticides, intermediate between the laboratory screening process and full-scale field tests by aircraft application. This is a crucial stage in testing insecticides for forestry use because the selection of insecticides can be narrowed to the most promising formulations and application rates for further field testing. The simulator reduces the number of aerial test flights needed and helps insure that aerial field tests, which cost from $50,000 to $100,000 each, are limited to those that are absolutely essential.

New device simulates pattern of insecticide sprayed from helicopter.

Chemical Treatments Protect Waterfront Structures From Decay

Results of a 13-year study at the Forest Products Laboratory have shown how to prevent decay in waterfront structures. Even though the above-water sections of these structures are treated for decay before installation, they become susceptible to fungal attack when the wood checks and untreated wood is exposed. Properly used, information from the study could save hundreds of millions of dollars each year in the United States alone.

Several treatments were effective. Annual application of fluor-chrome-arsenic-phenol (FCAP) completely prevented decay of southern pine decking during the 13 years of the field test. Douglas-fir planks treated annually with applications of sodium pentachlorophenol, penta in oil, or FCAP were also free from decay. Pile tops have also remained sound when treated either with penta-grease or ammonium bifluoride in holes drilled into the piles. Treating pile tops with sodium penta or penta, followed by application of a capping compound, also completely protected the wood.



Treated pile top with protective cover.

Effects of Nitrogen Pollution Noted in Southern California

Emissions of nitrogen oxides into the air in the south coast basin of southern California are among the highest in the nation. As a result, nitrogen oxides are a major source of acid rain and nitrate water pollution in the mountain watersheds of the Angeles National Forest.

Scientists at the Pacific Southwest Station, in cooperation with the University of California at Riverside, are studying the ways in which nitrogen from the polluted atmosphere enters, is transformed into, and leaves plant, soil, and water systems. Their research paints a dismal picture of the effects of excessive nitrogen on water quality and forest productivity. The problem is particularly severe in chaparral, because the massive, leafy shrubs filter pollutants out of the air. Because yearly rainfall in southern California is concentrated into a short period, the pollutants tend to wash off all at once, flooding the soil and water with excessive nitrogen. Researchers have also found a strong relationship between the amount of streamflow and nitrogen concentration; that is, the lower the water, the higher the concentration of nitrogen. The problem is compounded by highly erodible soils that do not provide a good "sink" for nutrients and because the short rainy period forces nutrient uptake, microbial activity, and vegetative growth into a short period.

Conversion of chaparral to grass also has an effect on nitrogen in the water. In one study, researchers found much more nitrogen in streams where chaparral had been converted to grass than in areas where chaparral was retained. There is also some indication that when soil is wet, the bacteria that convert ammonium to nitrate also produce gaseous nitrous oxide, which escapes into the atmosphere. The nitrogen loss affects forest productivity and the nitrous oxide breaks down the ozone layer that protects the earth from harmful ultraviolet radiation.

These findings are important in deciding whether to convert chaparral to grass and in timing prescribed fires. And, in the biological sense, they are inmportant because they document the degree to which air pollution is affecting the health of natural ecosystems and the environment for people in the Los Angeles basin.

Research will continue through 1985 under a grant to the University of California from the Man and the Biosphere Program of the U.S. Department of State and United Nations Educational, Scientific, and Cultural Organization. The grant is administered by the Consortium for the Study of Man's Relationship With the Global Environment.

Size and timing of prescribed fires can affect both air and water quality.

Bioassay Technique Used to Assess Nutrient Losses in Soil

Researchers at the Pacific Northwest Station have used a standard bioassay technique to quickly assess the potential effects of erosion, particularly nutrient loss, caused by wildfire and timber harvest activities.

The bioassay technique involves growing grass and trees in soils from which various surface layers have been removed to simulate soil loss. After growing in a greenhouse for 6 months, the plants were analyzed for growth and mass. Results showed that although the loss of any soil layer causes a drop in productivity, the top layer is the most crucial. The productivity of some forest soils can be reduced markedly with a loss of even less than the top 3 centimeters of the surface layer.

Using a bioassay technique is important because it provides a quick approximation of the impact of erosion loss and early growth response. The ultimate effect of erosion, however, may not be known until the next harvest, perhaps 100 years or more hence.

This information has been widely disseminated to land managers and resource specialists in the Pacific Northwest through workshops and training sessions. Forest Service soil scientists are using the technique to recognize soils particularly sensitive to loss of productivity by erosion. Guidelines can be prescribed that will reduce adverse impacts of forest management activities.

A bioassay technique in a greenhouse can quickly assess impacts of timber harvest on soil.

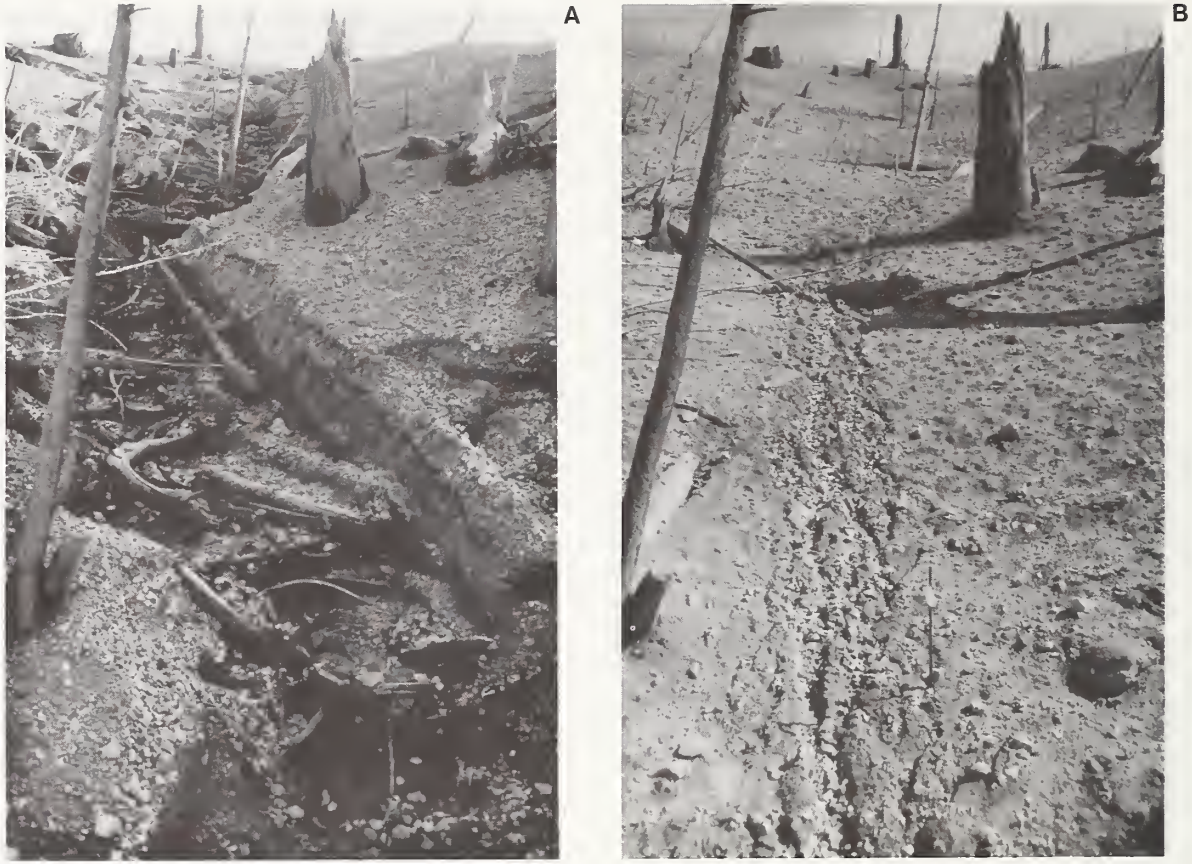
Scientists from the Pacific Northwest Station started studying erosion in the forested areas devastated by Mount St. Helens within weeks of its eruption in 1980. Designed to assist Federal, State, and local agencies concerned about watershed problems, the research so far shows that:

• Salvage logging of damaged timber reduces surface erosion by creating a soil surface that is more permeable than crusted ash. When new volcanic deposits are mixed with old soil, infiltration rates are increased and overland flow of water is decreased.

• Erosion from hillsides is a minor source of sediment in some areas and major in others, depending on the depth and location of volcanic deposits.

• Artificial seeding of grasses had little effect on the initial large pulse of surface erosion that came with the first heavy rains after the eruption, before the grass was well established. Success of artificial seeding varied with depth of ash, erosion rate, elevation, and type of native vegetation present before the eruption. Over most of the blast zone, the plants that came back fastest were those that survived as rootstocks below the ground surface or in snowpacks.

Information from these studies has been shared with the Soil Conservation Service, U.S. Geological Survey, and planners from the Gifford Pinchot National Forest and Cowlitz County, Wash. Research results have been communicated through briefings, written reports, and training sessions and have been important in designing timber salvage and watershed rehabilitation programs. International interest has also been shown in the work, particularly from Japan and Costa Rica.



Erosion potential in the devastated area at Mount St. Helens is shown by pictures taken 4 months apart: September 1980 (A) and January 1981 (B).

Overburden spoils from phosphate mines in the West have proved difficult to revegetate because of the infertile nature of the spoil material; steep, unstable slopes; high surface temperature; low precipitation; and sometimes unauthorized grazing by domestic cattle. A concerted program of research, development, and application over the past 10 years at the Intermountain Station has provided some solutions to the problems. As a result, phosphate spoils can now be successfully reclaimed.

In the first stage of the project, several treatments designed to establish vegetation and accelerate natural succession were tested. Both native and introduced plant species were tested along with different fertilizers, mulches, and irrigation treatments. All study sites were level and free of influences associated with slope and aspect.

During the second stage, the species and species mixes that did best in earlier tests were tried on more difficult sites. Grazing studies to test different treatments and species mixes were done at Gay Mine near Pocatello, Idaho. Studies of revegetation of steep slopes with high surface temperatures were conducted at Maybe Canyon and Ballard Mines near Soda Springs, Idaho.

Scientists have determined which seed mixes work best on different types of sites. Research will continue in an effort to learn the effect of various treatments on plant succession and on long-term productivity on the sites.

In stage three, pilot-scale revegetation efforts have been undertaken. The methods developed in the project are now in use by most of the western phosphate mining industry; 75-percent vegetative cover in the second growing season is not unusual. Scientists also had a hand in getting into use various types of equipment used for revegetation purposes. The equipment was selected, evaluated, and recommended—based on what had worked best during the research. Recommendations were passed along to the industry through on-the-job training, technology transfer sessions, reports, and publications.

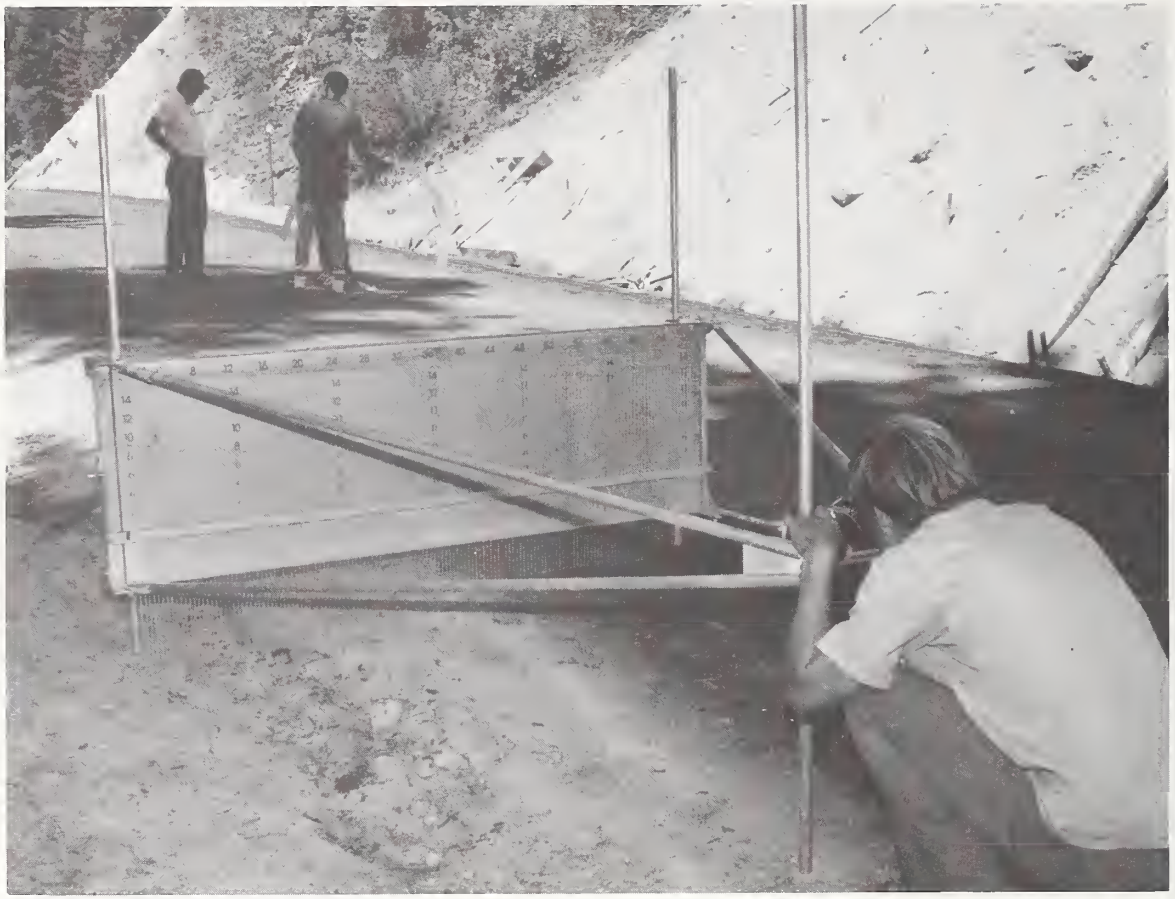
Overburden spoils from phosphate mines can be revegetated using various treatments developed at the Intermountain Station.

Procedures Developed for Estimating Sediment Yield

Procedures have been developed for estimating the average annual sediment yield from forest lands in the Northern Rocky Mountains. Most of the data base came from over 20 years of research at the Intermountain Station on erosion and sedimentation from granitic soils of the Idaho batholith. Specialists from the Station and the Intermountain and Northern Regions of the Forest Service developed the procedures.

The inventory data are organized by landscape segments with distinct geomorphic characteristics. These areas become the basic "erosion response units" for a watershed. The guides predict sediment yield from watersheds in the undisturbed state and yields in response to various management activities—different types of roads, logging practices, and wildfire of various intensity for any number of years. The models simulate what would happen in a managed forest by: (1) predicting site erosion from a given activity, (2) modifying the amount of erosion according to the activity and prevailing rock type, (3) delivering the eroded material to the stream, (4) routing it through the watershed to a critical stream reach where interpretations can be made, and (5) monitoring for conformance to planned activities.

The procedure is a good way to compare alternative mixes of land management practices and their effects on erosion from forested watersheds. Using the procedure, land managers should be able to keep sediment increases at an acceptable level. Long-term evaluation of cumulative effects of management activities is also possible for larger watersheds. The procedures are in use by several National Forests in the Northern and Intermountain Regions and are being adapted for other areas, such as coastal Alaska.



Data from 20 years of research have been used to develop procedures for estimating the average annual sediment yield from forest lands in the Northern Rocky Mountains.

Oldtimers have long claimed that the snow on the windswept high plains of the West does not get a chance to melt, "It just wears out by blowing back and forth." Scientists at the Rocky Mountain Station have now given credence to their observations. Researchers found that near-constant winds on the high plains relocate most of the winter snowfall. As the tiny crystals of broken snowflakes are herded over the ground by blizzard winds, many simply evaporate. Using photo-electric particle counters, elaborate electronics, and sophisticated mathematics, the scientists found that about one-third of the snow that falls during a frigid, nighttime blizzard may be lost to evaporation—about 100 times more than if the fallen snow had remained in place.

The resource management tie? You might have guessed—water. These evaporation losses are serious on the semiarid high plains. Scientists are using their new knowledge of snow physics to design snow fences and other structures to trap snow, thereby minimizing evaporation and increasing water available for vegetation or human use.

Using elaborate electronics and photo-electric particle counters, scientists have shown that about one-third of the snow that falls during a nighttime blizzard may be lost to evaporation.

Water Quality Data Base Developed

A water quality data base has been developed by the Northeastern Station for the coalfields of eastern Kentucky, West Virginia, and Maryland. It will help in predicting the effects of surface mining and reclamation activities on streamflow and water quality and may make it possible for many mines to remain open and productive in the future.

For 2 years, 124 small watersheds in eastern Kentucky, 118 watersheds in West Virginia, and 9 watersheds in Maryland were sampled monthly. Samples were analyzed for common ions, alkalinity, acidity, pH, nitrogen, phosphorous, trace elements, electrical conductance, turbidity, suspended solids, and solids that settle out.

The data base can be used to develop mining and reclamation schemes that minimize adverse effects on the environment and assist in meeting permit requirements. Specific users include regulatory agencies, mine operators, reclamation associations, consultants, land-use planners, landowners, and environmental groups.

In related work, scientists conducted a survey of the coal overburden (mineral and vegetation material overlying coal seams) in the Warrior Basin in Alabama in cooperation with the Bureau of Land Management (BLM), U.S. Department of the Interior. The bureau had been concerned about the potential for toxic elements to leach into water or to prevent plants from growing back. But researchers found little toxic material. The information will be of use to BLM in deciding whether to lease Federal lands for coal mining in the Warrior Basin, and it will help in deciding which plant species should be used to revegetate sites disturbed by mining.

Streams in watersheds in Kentucky, West Virginia, and Maryland were sampled monthly for 2 years.

Caribbean Foresters Identify Forestry Needs

The first meeting since 1946 of Caribbean foresters, held in May 1982 on the island of Saint Lucia, led to agreement on a number of important tropical forestry matters. This workshop was sponsored by the Southern Forest Experiment Station, the Man and the Biosphere Program, the Ministry of Agriculture of Saint Lucia, and the University of Puerto Rico's Center for Energy and Environment Research. Attendees discussed a long list of tropical forestry problems and opportunities facing island managers and identified the following needs:

1. A forestry training course for junior officers in forestry organizations on the island.

2. Better research information on management of tropical watersheds, management of secondary forests and degraded lands, recovery of forests from catastrophic events, selection of suitable plantation species for Caribbean Islands, and linkages among forests and uses of upland and coastal ecosystems.

3. Prescriptions for watershed management in steep and wet tropical regions.

4. Hurricane contingency plans for each island.

Participants also agreed on the need to establish a Society of Caribbean Forestry and for the society to publish a summary of forestry activities each year based on reports from island foresters. Island foresters will also provide forestry statistics to the Institute of Tropical Forestry for summarization and dissemination.

In the Carribean, recently abandoned pastureland and cropland are often rapidly overgrown with ferns or brush, delaying establishment of a forest stand.

The 5.5 million acres of land dominated by aspen in the West are renowned for their multiple-use values. Few timber types produce as much livestock forage, wildlife habitat, timber, water, and scenery. In the future, however, demand for aspen will most certainly increase, particularly for fuelwood. As harvesting becomes more intensive, more information is needed to adequately manage aspen stands—and to make certain all resource values are protected.

Scientists at the Intermountain and Rocky Mountain Stations are providing basic information on the variability of aspen lands for resource production. A number of aspen community types have been described. These classifications provide keys for identifying the types and information on vegetation composition, productivity, environment, and successional status.

Most aspen stands in the West are subclimax; that is, they will be succeeded by conifer-dominated forests if undisturbed for a long time. Such a change would reduce forage, plant and wildlife diversity, water yield, and scenic values. Researchers have found that both fire and clearcutting stimulate aspen reproduction and increase undergrowth, although the composition of the undergrowth differs appreciably, depending on the treatment used. They also found that clearcutting produces more aspen sprouts but relatively few lasting changes in understory plant characteristics. Cattle and deer used clearcuts more than uncut stands in aspen forests, but elk showed no response to clearcutting. Species of wildlife that require mature forests were most affected by clearcutting. Clearcutting and creation of openings for roads should benefit species needing sparsely vegetated areas and forest edges, as well as those favoring tall, dense, shrublike habitats provided by aspen sprouts.

At Intermountain Station, scientists have also developed a computer model that simulates successional changes that occur in the aspen ecosystem after disturbance such as fire or clearcutting. Changes in the vegetation—aspen, conifers, shrubs, or forbs—result in changes in multiple-use values. The model is being used as a predictive tool for resource decisionmaking and for research purposes.

The 5.5 million acres of aspen lands in the West are important for their multiple-use values.

Continuous Yearlong Grazing Has Advantages

Experiments conducted by range scientists at the Pacific Southwest Station and the University of California at Davis indicate that continuous yearlong grazing has considerable advantages over seasonal grazing.

Changes in total herbage production and botanical composition of 14 plant categories were studied under three grazing systems tested at the San Joaquin Experimental Range in the Sierra Nevada foothills: (1) continuous yearlong grazing; (2) rotated seasonal grazing (grazing only one season, the same each year); and (3) rotated seasonal grazing (grazing only one season, different each year). The year was divided into three grazing seasons: inadequate green (October 15-February 1), green (February 1-May 15), and dry (May 15-October 15).

Weight gain of both cows and calves was consistently better on the yearlong grazing system. From the beginning to the end of the study (7 years), average cow weight increased from 744 to 1,058 pounds for yearlong grazing (system 1), from 746 to 951 pounds for system 2, and from 756 to 951 pounds for system 3. Calf weight increased a similar amount.

Total herbage production was not significantly different between the grazing systems. But different grazing systems did affect the percentage of various plant species on the rangeland. Range managers might use this information to selectively encourage or discourage certain species; for example, production of ripgut brome, a major forage species on many grasslands, was dramatically reduced when grazed repeatedly during the green season and was highest on areas grazed repeatedly during the dry season. Ripgut brome has a sharp awn that can injure animals. Seven other plant categories, including clovers and filarees, were also significantly influenced by differences in grazing systems.

Continuous yearlong grazing has considerable advantage over seasonal grazing in California; one big advantage: better weight gain for both cows and calves.

Do-It-Yourself Trail Registration Successful

For many years, recreation managers have used unstaffed trail registers at trail heads to collect information about trail use. The problem is, not everyone registers. To find out how to encourage more visitors to sign in, North Central Station recreation researchers used an electronic surveillance system (trail traffic counter and Super-8 movie camera) to monitor response to two types of registration—voluntary and mandatory. The voluntary approach gave trail users the choice of registering or not registering. The mandatory approach required users to register with signs that read, "One person from each group must register here."

Results showed that the unstaffed stations are indeed effective: People responded equally well to both approaches. But scientists recommend the voluntary approach, with a sign at the station telling people why registration is important. The less obtrusive the approach, they believe, the better it may fit with people's ideas about the outdoor experience.

System Developed To Minimize Recreation Regulations

Some regulations are necessary in managing forest recreation areas; in many cases, however, the regulatory approach can lead to strains between visitors and land management agencies. An alternative is indirect management, basically "soft sell." With this approach, managers seek to shift use patterns and alter visitor behavior, but in a way that is not offensive to visitors.

Too many regulations can be counterproductive, especially in wilderness areas. The objectives for wilderness management, however, seem to make regulation necessary. This presents a real challenge: how to achieve wilderness management objectives and still retain freedom of choice for users.

To help determine whether regulations are necessary, researchers have developed a seven-step system: (1) problem identification, (2) determination of causes, (3) identification and evaluation of potential nonregulatory approaches, (4) acceptance or rejection of the approaches, (5) identification and evaluation of regulatory approaches, (6) acceptance or rejection and further analysis, and (7) implementation and monitoring of effectiveness and costs.

Use of the system should result in fewer, but better, regulations. Regulations adopted after analysis should contribute to resource protection and to rewarding experiences for visitors over the long run.

Researchers recommend a voluntary approach to trail registration and a "soft sell" approach to people management in wilderness areas.

Habitat Needs Defined for Scaled Quail

The scaled quail is the most popular upland game bird in the Southwest United States. Its range includes parts of Colorado, Kansas, Oklahoma, Texas, New Mexico, and Arizona. Biologists have shown that the seeds of mesquite are an important year-round and highly preferred dietary staple of the quail. The bird also needs cholla cactus and other low shrubs for cover. But mesquite and cactus are pest plants on rangelands, and the bird's need for food and cover sometimes comes out second best when cattle growers clear brush for range improvement.

Researchers at the Rocky Mountain Station have developed guidelines for integrating management of quail and livestock. Ranchers who want to supplement their income through fee hunting now know they can maintain relatively high quail populations by retaining as little as 10 percent of the habitat in a mosaic of small clumps of mesquite. Some low brush cover must also be preserved for daytime resting and nighttime roosting. Quail need about 1 percent of their habitat as low, thorny shurbs that shield tall grasses from grazing cattle.

Scaled quail use a walkingstick cholla cactus for daytime resting cover.

Wildlife Books Completed

The Pacific Northwest Station has contributed two major new books on wildlife and wildlife habitat.

"Natural History of Oregon Coast Mammals," General Technical Report PNW-133, was published cooperatively with the Bureau of Land Management, U.S. Department of the Interior. It provides information on the biology, habits, and life history of the 96 species of mammals found along the Oregon coast. The wildlife species, of which 65 are terrestrial and 31 marine, are related to their habitat: The geological, soil, and vegetative conditions found along the coast. The extensive life histories are based on both published and unpublished sources and provide a dynamic view of the habits of the mammals and their habitat.

"Elk of North America: Ecology and Management," was edited by a Forest Service wildlife biologist and published by the Wildlife Management Institute. Twenty-seven widlife specialists from all over the country contributed to this compendium of the latest scientific information on elk. The 698-page book traces the history of the elk and chronicles the circumstances of its decline and recovery. Information is included about the animal—its physiology, behavior, habitat, relationship to other species, population dynamics—and the management practices necessary to maintain elk populations.

These two books are being used by resource managers, scientists, and students in the United States and Canada. Because of these compilations, managers can make better use of the existing knowledge to improve resource management practices. Researchers benefit, too, by being able to discern the areas of research that need additional study.

The chickaree occurs along the entire Oregon coast and inhabits a variety of forest habitats.

Implications of Agricultural Strategies Outlined for Douglas-Fir

The notion that the strategy that produced the "Green Revolution" in agricultural crops such as corn, wheat, and rice many be applicable to management of Douglas-fir is evaluated in a report from the Pacific Northwest Station: "Nitrogen, Corn, and Forest Genetics: The Agricultural Yield Strategy—Implications for Douglas-fir Management," General Technical Report PNW-137.

The basis of the agricultural strategy is to increase the number of grain-bearing stalks per acre by upgrading crop uniformity and harvestability and by enhancing the site: Relieving the constraints of drought, competition, cold, infertility, insect and disease problems, and lodging (beating down by wind or rain).

Most agronomic methods to increase yields are difficult to use in Douglas-fir management except in forest nurseries or for short-term crops such as Christmas trees. Severe limits are identified for nearly every potential agronomic technique available to relieve growth constraints. Because neither genetics nor spacing enhances the site, their contribution to yield, as in agriculture, is considered to be indirect—primarily by increasing the amount of the crop that can be harvested.

An added complication for Douglas-fir is a precise, probably templatelike, adaption of the tree to landform—elevation, latitude, aspect, and slope. In nature, this adaptation insures high survival and crop reliability. Agricultural crops were originally as precisely adapted and reliable. With improved agronomy, however, the agricultural plants were shortened to avoid lodging and slimmed to permit close planting. Ecological instability of the new genetic population required added pest control and continuous breeding effort. Such intensive management practices appear impractical for Douglas-fir.

The research report concludes that the genetics of locally adapted forests need not be greatly changed for most sites because the upper limit of improved yield for intensive Douglas-fir management is modest. This upper limit depends primarily on how much enhancement of the site can be indefinitely maintained above natural carrying capacity. A new, faster growing population would appear necessary with any permanent site enhancement, but such a population would probably be less stable than natural populations and would become relatively unadapted if site enhancement were discontinued.

Most agronomic methods to increase yields are difficult to use in Douglas-fir management.

Environmental Impacts of Intensive Forest Management Studied

On the southern Coastal Plain, many forest managers try to maximize yields of slash pine by burning and bedding planting sites, applying fertilizer, using genetically improved seedlings, and harvesting stands when they are relatively young. But many questions have been raised about the environmental effects of such treatments. In 1976, the Forest Service, forest industry, and the University of Florida established the Intensive Management Practices Assessment Center (IMPAC) on the university campus at Gainesville to learn more about the environmental impacts of intensive management of slash pine.

Long-term studies were established to measure changes in water quality, wildlife populations, and soil fertility. Important results so far were described during a symposium at the University of Florida in 1982. Researchers reported the following conclusions: (1) On flat areas, where intensive forestry is usually practiced, effects on water quality are slight and can be minimized by leaving untreated strips along streams, (2) Fertilizer will probably have to be applied to maintain soil productivity on areas managed for short timber rotations, (3) With or without intensive management, pine flatwoods are not attractive habitats for many species of wildlife, (4) Areas of cypress are heavily used by wildlife and should be maintained, and (5) The vegetation that develops in the years immediately after pine stands are clearcut is particularly attractive to bobwhites.

The corporations and agencies sponsoring IMPAC are eager for the research results, often putting them to use before they are published in scientific journals.

Abundant herbaceous growth providing food and cover for wildlife follows clearcutting and site preparation in the Bradford Forest Experimental Watershed, Fla.

Managing Tree Pollen Subject of New Book

In forest tree breeding, control of the male parent is achieved by collecting pollen from male flowers and applying it at the proper time to female flowers. Collecting, processing, storing, and using pollen, therefore, are keys to successful tree breeding. Relatively little research has been done on pollen management in forestry, but geneticists and breeders have gained a wealth of practical experience, particularly in the South, where forest tree improvement programs are most advanced.

The Southeastern Station has gathered all this experience into a single volume, "Pollen Management Handbook," USDA Agriculture Handbook 587, for sale by the Superintendent of Documents. Emphasis is on pollens of southern pine because these species are the best understood, but chapters on southern hardwoods, European black alder, and several eucalypts are also included.

During controlled pollination, pollen cones are covered with bags to prevent contamination. Later, the bags are removed; the pollen is applied to the pollen cones; and the cones are rebagged.

Synthetic Auxins Stimulate Rooting

Mass cloning of forest trees may be useful in reproducing genetically desirable traits. Rooting of cuttings is biologically desirable but is impractical for cloning large numbers of forest trees because many commercially important species—such as the pines—are nearly impossible to root. This severely limits large-scale production of cloned planting stock in commercial forestry.

Applying synthetic hormones, called auxins, to cuttings can stimulate rooting, but usually not enough. Researchers at the North Central Station have been learning how to make synthetic auxins more potent in promoting rooting of forest tree cuttings.

Three new and more potent classes of synthetic auxins have been identified and synthesized. Commercial methods for synthesis of the new auxins have also been developed in cooperation with the South Dakota School of Mines and Technology. These new phenyl-modified auxins are much more potent than the parent hormones; rooting of jack pine, for example, is twice as fast.

Faster rooting increases survival of cuttings and promotes better plant development. In addition, propagation facilities can be used more economically.

Jack pine cuttings are treated with an auxin solution before being placed in the rooting medium.

Natural Regeneration of Ponderosa Pine in the Southwest: Tough But Possible

Many factors combine in the semiarid Southwest to make life difficult for tiny seedlings of ponderosa pine. High temperature, low humidity, sporadic rainfall, competing grasses, heavy-footed livestock, and hungry wildlife—in various combinations—have prompted most foresters to favor planting nursery-grown seedlings over natural regeneration. Planting is usually successful if carefully done, but costs are high—roughly $300 per acre for bare-root ponderosa pine seedlings.

Using results from several small research studies, however, scientists at the Rocky Mountain Station and foresters on the Apache-Sitgreaves National Forest have achieved natural regeneration on large management areas. Thorough mechanical site preparation in the fall was timed to coincide with good cone crops; rodents were controlled; and emerging seedlings were protected from grazing livestock. As a result, over 11,000 acres were successfully regenerated at a cost of $25 to $40 per acre. These successes have been achieved primarily on sedimentary soils; frost heaving is still a major hurdle on basaltic soils.

More than 11,000 acres have been successfully regenerated with ponderosa pine seedlings in the semiarid Southwest, a result of the close cooperation of researchers and forest land managers.

"Lifting Windows" Defined for Douglas-Fir

The Forest Service's Humboldt Nursery in California is a critical link in reforestation programs for Douglas-fir in southern Oregon and northern California. The nursery produces planting stock for hundreds of seed sources in several climatic regions.

A critical factor for survival of seedlings planted in the spring is the date in winter when seedlings are dug from the nurserybeds and put in cold storage. Researchers at the Pacific Southwest Station have now defined the periods of time—the "lifting windows"—in which Douglas-fir seedlings from a particular source can be safely lifted and stored at the nursery. The lifting window spans 1, 2, 3, or 4 months from mid-November to mid-March depending on the geographic location of the seed source. Sources from the same geographic area have nearly the same lifting window. With a few important exceptions, the width of the window increases from south to north, from the Pacific coast to the interior Cascade-Sierra Nevada, and from low to high elevation.

Tests over periods up to 5 years showed that the lifting windows are specific and stable. Large differences in the fall and winter climate in the Humboldt Nursery area have little effect on the window of any seed source. Two-thirds of the seed sources have windows of 3 months or more, which enables the nursery to take full advantage of the best soil conditions for lifting during the winter and to pay special attention to seed sources with narrow windows.

Working within these guidelines, the Humboldt Nursery can produce seedlings that will survive at rates of 90 to 99 percent the first year, provided the plantings are protected against vegetative competition and animal damage. In contrast, survival of seedlings lifted outside the appropriate window will be low and almost automatically mean failure of the plantation.

Information on the lifting windows was gained from field tests of seedling survival conducted in the zone of seed origin for more than 50 seed sources from 30 seed zones. The tests were a cooperative effort of the Pacific Southwest Station, the Humboldt Nursery, the Bureau of Land Management, and 12 National Forests in northern California and southern Oregon.

Seedlings are lifted at the Humboldt Nursery in preparation for planting. The time of lifting is crucial to seedling survival in the forest.

Information Summarized for Mixed Conifer Forests in Oregon and Washington

Foresters have received help in managing 6 million acres of forest in Oregon and Washington from "Silviculture of Mixed Conifer Forests in Eastern Oregon and Washington," General Technical Report PNW-121, published by the Pacific Northwest Station.

Species common in these mixed conifer stands are Douglas-fir, ponderosa pine, western larch, lodgepole pine, grand fir, white fir, subalpine fir, western white pine, Engelmann spruce, Shasta red fir, mountain hemlock, western hemlock, and western redcedar. These species are somewhat intolerant of drought and therefore occupy sites at higher elevations where more moisture is available.

The publication summarizes 10 years of research at the Forest Service Silviculture Laboratory in Bend, Oreg. General guidelines and recommendations for silvicultural prescriptions are given. Use of the guidelines can result in increased productivity on public and private mixed conifer forests in eastern Oregon and Washington.

Management guidelines can increase productivity of mixed conifer forests in eastern Oregon and Washington.

Low-Cost Alternatives for Regenerating Mixed Stands of Loblolly and Shortleaf Pine in the South

Timber production can be increased on private, nonindustrial properties in the South if low-cost silvicultural and timber management alternatives are available.

The Southern Station reports results of a 36-year study of four silvicultural methods for naturally regenerating mixed stands of loblolly and shortleaf pine. The cutting methods included two even-aged management systems (seed-tree and clearcutting) and two uneven-aged systems (selection and diameter-limit). The results are good news for forest managers: All four methods can provide adequate, low-cost regeneration. Seed-tree and diameter-limit cutting methods produced significantly more cubic-foot volume than did selection cutting and clearcutting. Clearcutting resulted in significantly less board-foot (Doyle) volume. Board-foot volume production among all treatments will probably equalize as time goes on because many trees on clearcut areas are just now reaching saw-log size. All four cutting methods have an advantage over artificial regeneration methods: lower establishment cost.

Natural regeneration guidelines have been prepared. They discuss basic principles of managing for natural reproduction, pros and cons of each cutting method, and "how to" instructions for various timber stand situations.

The research results and management guidelines are being used by Service foresters throughout the South as they provide technical assistance to private, nonindustrial forest-land owners. A significant number of acres of private, nonindustrial holdings are being placed under management; these acres would otherwise have remained unproductive because of the high cost of establishing and managing plantations.

Natural regeneration of loblolly and shortleaf pine can be achieved with four different silvicultural methods. (A) Mixed stand of loblolly and shortleaf pine shortly after a seed-tree cut was made in 1942.

(B) Same area 15 years later and before removal of the seed-tree overwood to release pine reproduction.

Computer Prescriptions Developed for Allegheny Hardwoods

At the Northeastern Station, researchers have developed a computer program that can analyze data and make silvicultural prescriptions for mixed hardwood and oak forests in the Allegheny Mountains. The program uses data on overstory, understory, and site factors collected from more than 10 years of research. This information, along with silvicultural guidelines, is then manipulated by the program to produce a recommended stand treatment complete with detailed instructions on how to apply the treatment.

In addition to tabular data, the printout includes a narrative description of the stand and the rationale for treatment, thus making it especially valuable to foresters working with landowners who lack forestry training. The program facilitates the analysis and prescription process on large ownerships and insures that even the most recent silvicultural guidelines are readily available and properly interpreted. The program is a timesaver for the professional forester, is especially useful for foresters who may not be familiar with the local timber types, and has many advantages for the consulting forester—who can pass the prescriptions along to landowners in a form they can use.

The program is being used by several organizations. Hammermill Paper Co. is using it to prescribe treatments and summarize inventory data for all their northern timberlands. Other users include Pennsylvania and New York State forests, Kane Hardwood Division of Collins Pine Colo., the Monongahela, Allegheny, and Wayne-Hoosier National Forests, and other industries and consultants. The program is also available through the Cooperative Extension Service of universities in Pennsylvania and New York.

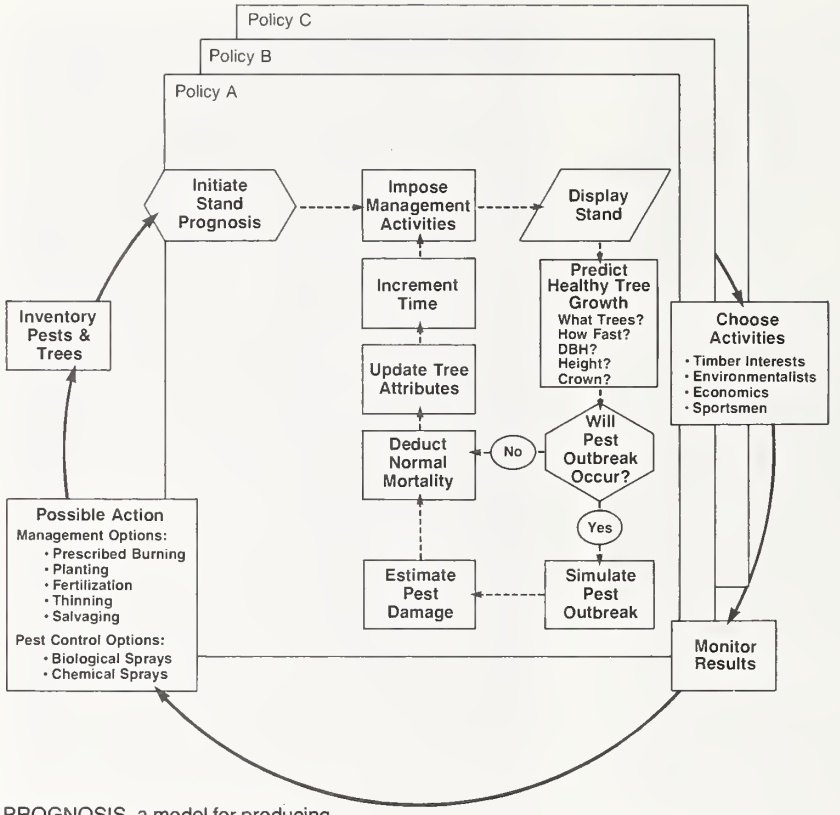
Computer prescriptions for Allegheny hardwoods include a narrative description of the stand and rationale for treatment.

Managers of public and private forest lands in the inland Northwest are using a prognosis model for stand development to predict how forests will respond to silvicultural practices. Since the model's introduction, several improvements have been made: (1) Additional silvicultural treatments have been included, (2) The capability to evaluate damage by the Douglas-fir tussock moth has been added, (3) The geographic range of usefulness has been increased, and (4) Economic analyses have been improved. Yield forecasts from this system are important in prescribing stand treatments and in scheduling harvests in intensively managed forests.

The combined prognosis/Douglas-fir tussock moth model translates the level of defoliation into a long-range forecast of expected timber harvest volumes and gives managers a more precise way to compare various strategies in integrated pest management.

Development of the stand prognosis models was possible because of earlier research; for example, the development of ecological classification systems for managed forests and for pest hazard rating and the development of methods for estimating effects of stand density control, weeding, and site preparation on growth. The basic model for stand development was developed by the Intermountain Station. The tussock moth outbreak model was developed by the Pacific Northwest Station and Oregon State University, and the two models were linked by the Intermountain Station as part of the USDA Expanded Douglas-Fir Tussock Moth Research and Development Program.

Access to computer systems is required to use the models, but managers without their own computer can use the system through several State university Cooperative Forestry Extension Services.



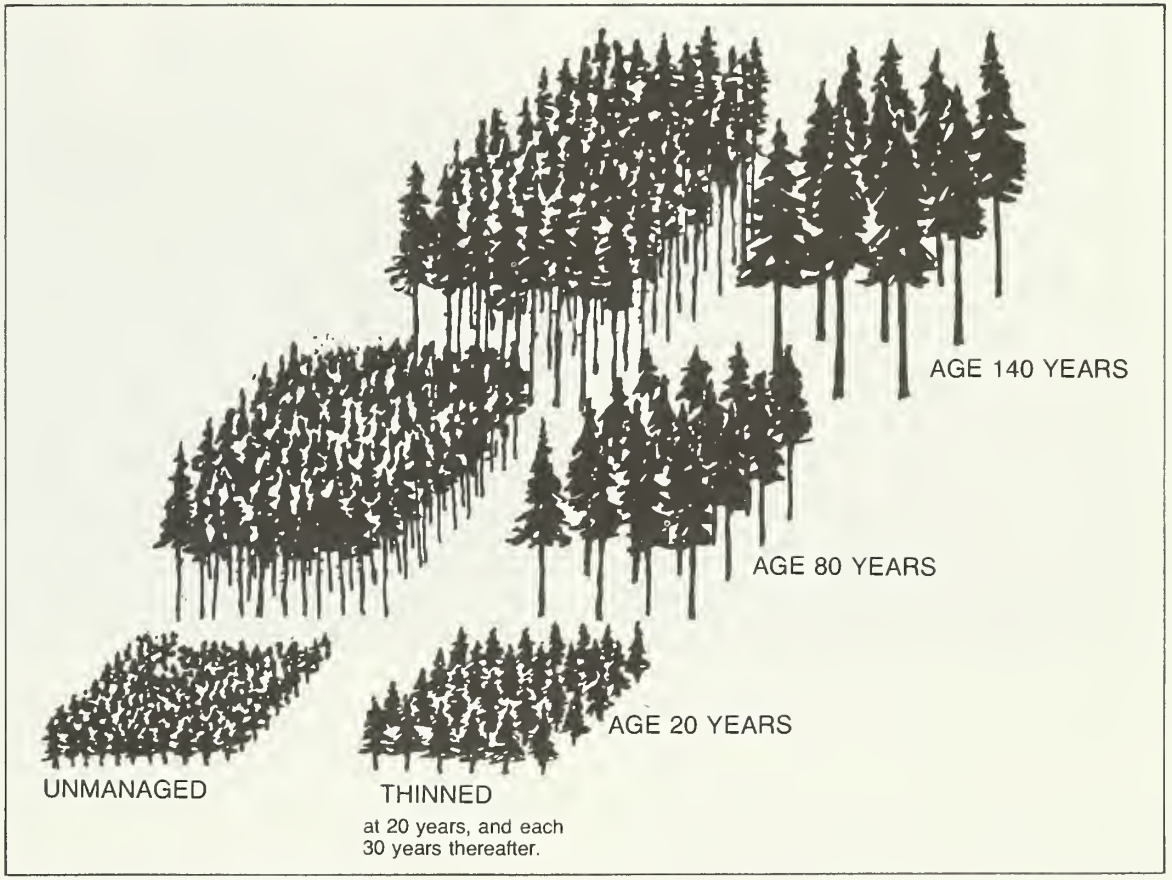
PROGNOSIS, a model for producing growth and yield tables, forecasts stand development strategies by simulating the growth and mortality of individual tree samples.

Crown Models for Lodgepole Pine Have Several Uses

Working on ways to predict growth in lodgepole pine forests, researchers at the Intermountain Station have developed models that provide estimates of vertical crown development as a function of dominant stand height and stand density in even-aged stands. When linked with existing tree and stand projection programs, the development of crowns and forest canopy can be predicted.

As a result, forest managers have a tool that can be used for a variety of purposes: To compare effects of different timber management practices on the canopy and to study the ways in which management practices might affect wildlife habitat, snow interception and melt, and water use and discharge from forested watersheds.

This technology has been incorporated into LP-STAND-GRO, a computer program that predicts growth of lodgepole pine stands and was adapted from RMYLD, a widely used computer program for estimating stand growth and yield in the Rocky Moutains. The crown models are being used by silviculturists, wildlife biologists, and planners in the Northern Region of the Forest Service. Researchers are also working to link the crown models to another computer program that predicts individual tree growth and stand development, in an effort to extend the models' usefulness to mixed species and uneven-aged stands.



Lodgepole pine showing canopy development under both thinned and unthinned conditions.

Research on Fire Prevention Pays Off in the South

Ten years of research at the Southern Station has paid off in a better understanding of fires caused by arson and in ways to solve the problem. Many wildfires in the South are caused by people who set fires on purpose—to burn the grass or to improve hunting, because they are mad at the landowners, or for other reasons. Research has demonstrated that personal contact is superior to any other form of communication in reaching these people with the fire prevention message.

The Southern Station has prepared a 16-hour training program designed to teach the importance of personal contacts in fire prevention and the traits necessary for that type of work. The program has been presented in six workshops across the South. Over 125 participants representing National Forests, State forestry agencies, the forest industry, and volunteer fire departments attended the sessions. Several participants have conducted workshops in their own organizations; consequently, about 300 people have received the training and more workshops are scheduled or planned.

Other followup activities include a soon-to-be-published self-study manual for contactors and adoption of the training by the Fire Prevention Working Team of the National Wildfire Coordination Group for inclusion in a comprehensive training program for fire prevention specialists throughout the United States. Distribution of training material and coordination of workshop planning has been taken over by the Aviation and Fire Management Staff of the Southern Region.

Research has paid off in a better understanding of fires caused by arson in the South.

Research Helps Forecast Forest Succession in Montana

Recent research is helping forest managers forecast both short- and long-term changes in forest succession caused by natural disturbances or forest management activities. In one publication, changes resulting from timber harvest and fire control are illustrated and interpreted. General Technical Report INT-130, "70 Years of Vegetative Change in a Managed Ponderosa Pine Forest in Western Montana," is available from the Intermountain Station. Vegetative changes are illustrated with photographs taken at the same locations at 10-year intervals between 1909 and 1979. Changes in vegetation are interpreted and implications discussed for managing timber, wildlife, fuels, esthetics, and livestock.

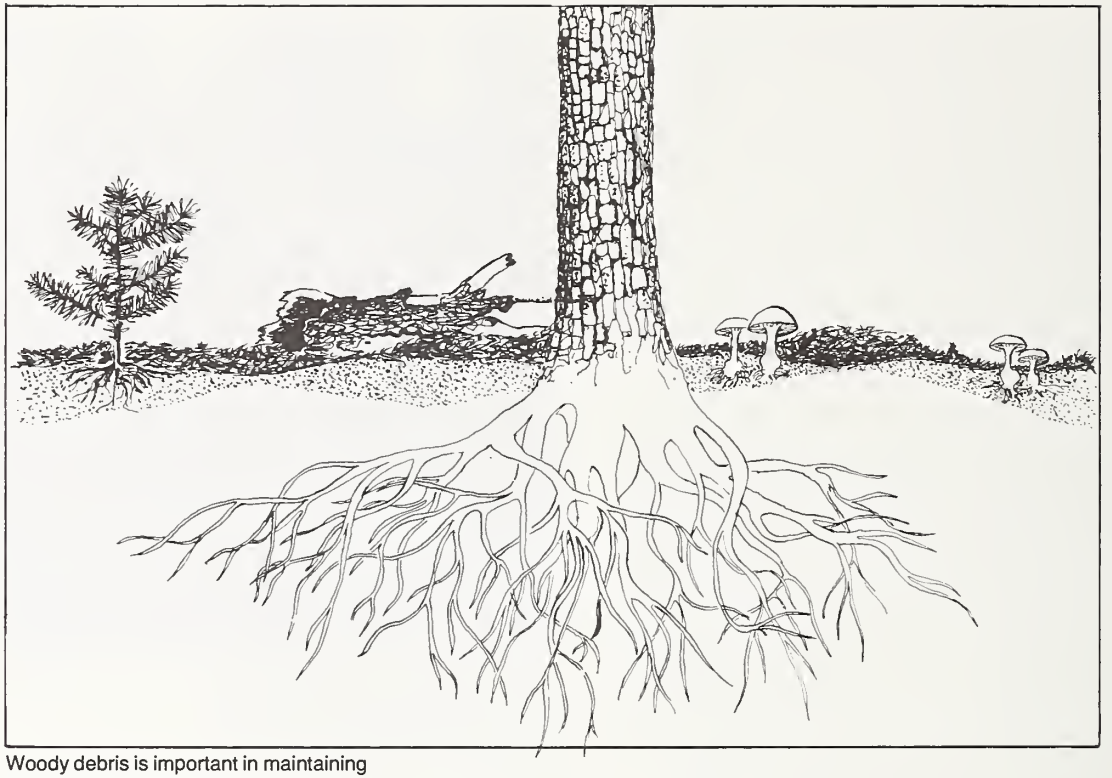
Another report, in preparation, documents the seral types (successional stages) that occur in each of four habitat types in the Douglas-fir and subalpine fir forests of western Montana. Habitat types are primary classifications of vegetation used to define the final "climax" stage of succession toward which natural vegetation will move if undisturbed by fire, logging, or other event. The seral classifications are based on a large number of sites where natural immature stands and treated managed stands occur side by side. Treatments include wildfire and clearcutting accompanied by mechanical scarification, broadcast burning, and pile burning. For each habitat type, the successional stages are described by structural characteristics and vegetative composition. Predictions are given for how long it should take to move from one stage to another and to reach climax type, given various management activities. Land managers are using this information to predict effective land management practices on a variety of natural resources in western Montana.

Natural succession in ponderosa pine-Douglas-fir forest after selective timber removal is illustrated in this pair of photographs: (A) 1909 (B) 1938.

Woody debris is important in forestry operations in the Northern Rocky Mountains to maintain organic reserves and to protect long-term productivity of the soil. Scientists at the Intermountain Station have demonstrated that much of the productive potential of forest soils in that region results from the nutrients, water-holding capacity, and microbial activities associated with organic matter derived from woody material.

Research shows that 10 to 15 tons per acre of woody debris (6 inches or larger in diameter) left after logging will provide an adequate base for soil organic matter accumulation in the next rotation. This is true for all forest types studied: Cedar-hemlock, grand fir, and particularly Douglas-fir on drier sites. In beginning this work, researchers were interested in determining the environmental effects of removing wood—a primary component of soil in forest ecosystems. They have found that woody material has several important functions: It is valuable as a substrate for ectomycorrhizal activity and for nonsymbiotic nitrogen fixation—especially on drier sites. In fact, during periods of drought on dry sites, microbial activity may take place only in woody material because rotten wood stays moist long after the rest of the soil has dried out.

This information was developed from research conducted at several extensively harvested sites in the Northern Rocky Mountains and was sponsored by the Intermountain Station, the Forest Products Laboratory, and Michican Technological University. The information has been published and is being used by National Forests in the Northern Rocky Mountains as a base for wood utilization and fire prescription standards.



Woody debris is important in maintaining organic reserves and in protecting long-term productivity of the soil.

Research Explains Odd Fire Pattern

Scientists at the North Central Station have proposed a theory to explain a unique pattern of burned and unburned vegetation that occurs during crown fires on level terrain. Mile-long, narrow strips of unburned tree crowns are sometimes left in the wake of a crown fire. In those areas, the trees are unburned, but the ground is black. To explain this recurring pattern, researchers have proposed a theory of air movement caused by "horizontal roll vortices."

Researchers believe the vortices are caused when rising gases along the perimeter of a fire meet the normal horizontal wind. This creates a wind shear that acts much like a dust devil on its side: The wind rolls forward in a spiral motion along the flanks of the fire, creating the odd pattern of unburned crown. The theory was developed from observations of forest fires in Michigan and New Jersey and from knowledge of fire patterns in other parts of the country.

Safety of firefighters is the major concern. The phenomenon may have caused the death of several firefighters. By combining laboratory findings with data from actual fires, researchers hope to learn how to predict when vortices are likely to occur, thereby increasing safety for firefighters. The research has application throughout the Eastern United States, southeastern Canada, Australia, and anywhere crown fires occur in relatively flat terrain.

Unburned strips resulting from the Bass River fire in New Jersey, 1978. The gray pattern shows burned pitch pine; white is unburned tree crowns.

Big sagebrush occupies extensive areas of the Western United States and Canada and poses problems for resource managers in both controlling wildfires and knowing how to prescribe fires for various purposes. An ability to accurately predict fire behavior is an important aspect of both jobs. Using a system developed at the Intermountain Station, forest and range managers can now estimate and predict the amount of sagebrush fuel in a given area and can predict fire behavior.

The system, a set of graphs, is based on computer models and is presented in Research Paper INT-290, "Fuel and Fire Behavior Prediction in Big Sagebrush." The user must input data on height and cover of sagebrush and weight of accompanying grasses and forbs. The system can then predict the rate of fire spread and the intensity of fire in sagebrush ranging in height from 8 to 47 inches (30 to 120cm) and from 10 to 40 percent cover. Other information—quantity of foliage and stemwood by size class, plant bulk density, and fraction of dead stemwood—is also produced as it must be computed to determine fire spread and intensity.

The system, based on 10 to 15 years of research at the Intermountain Station, demonstrates the current state of knowledge in modeling fuels and fire behavior in sagebrush. Range and fire management are the primary beneficiaries, but researchers and those interested in plant ecology and biomass may also find the work useful.

Fire behavior in big sagebrush can be predicted with a set of graphs based on computer models.

Satellite Imagery Used To Map Forest Fuels

Fire management policies of many land management agencies require accurate methods of assessing the risk of fire over large geographic areas. As a result, data bases that describe the vegetation and litter as fuel are necessary for many fire management purposes and for research on fire modeling techniques.

The problem is how to gather data over large areas economically but make them detailed enough to be of local use. Results of a pilot study at Intermountain Station show that forest vegetation types can be mapped over large areas and interpreted locally as "fuels" by combining two types of information: satellite imagery and digital terrain data. The mapping system may substantially reduce costs over current manual inventory methods.

Researchers used satellite data stored at the Earth Resources Observation System Data Center in South Dakota, a cooperator in the work. The digital terrain data came from the U.S. Coast and Geodetic Survey. Ground truth data points were established to teach the computer how to discern fuels from the satellite imagery and the terrain data. The new techniques are being used by the National Park Service in Yosemite National Park and by the Bureau of Land Management, U.S. Department of the Interior, in eastern Oregon and Alaska. Both agencies have adapted the mapping system for their own purposes.

Intermountain Station has also published a guide for selecting fuel models for use in predicting fire behavior on specific sites where better delineation of fuels is required. Descriptions and colored photographs illustrate typical or "model" fuels. These fuel models are being used in training sessions for forestry professionals sponsored by the interagency National Wildfire Coordinating Group.

Intermountain Station's guide for selecting fuel models contains descriptions and color photographs that illustrate typical fuels.

Models Developed for Timing Prescribed Fires

The key to reducing air pollution and soil damage from prescribed fires, such as slash burning, is the moisture content of the large, woody fuels being burned, according to researchers at the Pacific Northwest Station. If too much duff is removed, the soil may erode; if the fuel is too wet, too much smoke can be produced. So researchers have developed a group of models that can determine the weather conditions necessary to produce the desired level of wood fuel consumption. This, in turn, will result in an acceptable level of duff reduction and air pollution.

The models can be used for planning, daily monitoring, or prediction purposes. They use meteorological data routinely available from fire-weather and remote, automated weather stations. The models include a precipitation and relative humidity "bookkeeping" system, an instrument to monitor and record precipitation, and fuel and duff consumption algorithms. The components of the system are being field tested in National Forests in the Pacific Northwest and Pacific Southwest Regions and by the Intermountain Station.

The new models are more precise than the present method of timing prescribed fires, which is to use fuel moisture measurements and personal judgment. If the new models are used in prescribed burning on westside National Forest in the Pacific Northwest, the following benefits can be expected annually:

- Near elimination of regeneration or erosion failures caused by too severe burning.

- Reduction of particulate emission to the atmosphere by at least 150,000 tons.

- Savings of at least $2 million in prescribed burning costs.

Moisture content of large, woody fuels is a key to timing of prescribed burning.

Firecast—A New Computer Model Estimates Fire Behavior

Fire scientists at the Pacific Southwest Station have developed an interactive computer model to help predict fire behavior in forests and wild lands. Called FIRECAST, the model and an accompanying user's manual are being tested by all National Forests in the Pacific Southwest Region, and by the California Department of Forestry, the Bureau of Land Management, and the National Park Service in California.

The model is unique among fire predictive tools in that it can process information from the fuel models of the National Fire-Danger Rating System, the Northern Forest Fire Laboratory System, and the Southern California Brushland System. With FIRECAST, one callup for a program will access all three of these systems and provide all of the information on fire behavior currently available in California. Other predictive systems may require several time-consuming callups. The FIRECAST system is readily applicable with all those systems. In addition, users can custom build the fuel and environmental data for the model, thereby creating site-specific tools for estimating fire behavior. The model also provides users of the Southern California Brushland System with the option of describing, for specific sites, the percentage of dead brush, its average depth, and the live moisture content of both new and old growth.

FIRECAST was developed at the request of principal cooperators in FIRESCOPE (Firefighting Resources of Southern California Organized for Potential Emergencies), a multiagency group that includes representatives of the California Department of Forestry and the fire departments of seven major counties in southern California.

Computer model integrates data on forest fuels and environmental conditions for use in predicting fire behavior.

Researchers at the Pacific Southwest Station are developing a mathematical model that planners can use to improve the economic efficiency of fire management operations. Called the "Fire Economics Evaluation System" (FEES), the model is designed to: Screen proposed budgets and options for fuel treatment, initial attack, aviation operations, and suppression of large fires; evaluate the economic efficiency of each option; estimate probabilities of program performance from year to year; and predict potential fire-related changes in natural resource outputs.

The model has several parts, in various stages of completion. One of the most recent additions is a segment to use weather data in predicting fire behavior. Because weather measurements are usually taken only at 2:00 p.m. each day and conditions may be very different throughout the day, the model "corrects" for expected weather conditions. A second addition is a more accurate way to calculate the losses in timber value—net value changes per acre. A computer procedure is also available for calculating the total economic cost of specific fire management activities.

Work is continuing on the model, and each new element is being put into use almost as soon as it is completed. The procedure for calculating net value change, for example, is being used to assess fire damage in the Northern Rocky Mountains. The model is expected to be completed in 1983.

The FEES model can be used to calculate costs for wages, food, supplies, and shelter for firefighting crews.

Products and Engineering

Improving Forest Engineering Systems

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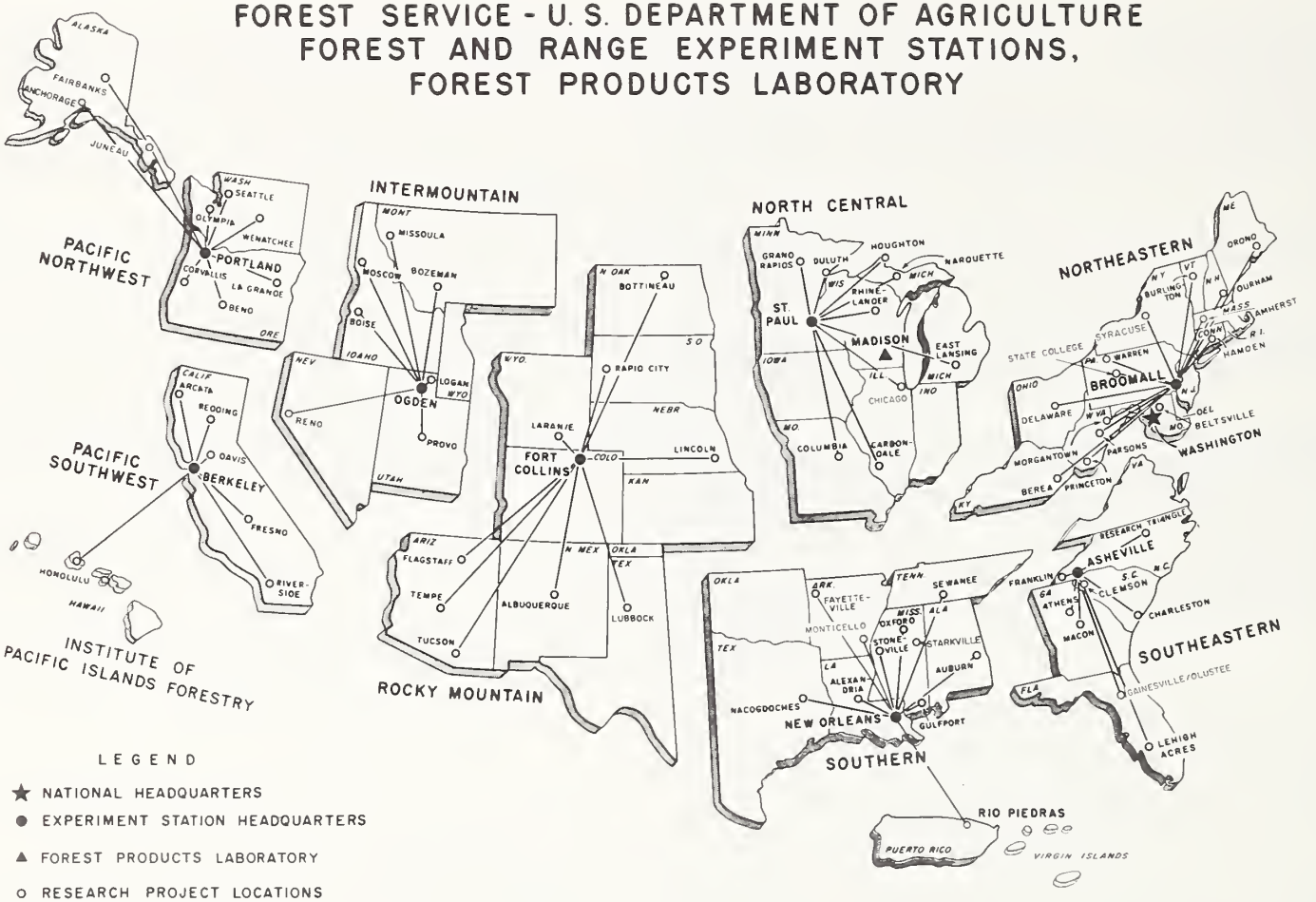

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